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► **To cite this version:**

Martin Dres, David Hajage, Saïd Lebbah, Antoine Kimmoun, Tàì Pham, et al.. Characteristics, management, and prognosis of elderly patients with COVID-19 admitted in the ICU during the first wave: insights from the COVID-ICU study. *Annals of Intensive Care*, 2021, 11 (1), pp.77. <10.1186/s13613-021-00861-1>. <hal-03524638>

HAL Id: hal-03524638

<https://hal.science/hal-03524638v1>

Submitted on 20 Jan 2022

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RESEARCH

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Characteristics, management, and prognosis of elderly patients with COVID-19 admitted in the ICU during the first wave: insights from the COVID-ICU study

Prognosis of COVID-19 elderly critically ill patients in the ICU

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Abstract

Background: The COVID-19 pandemic is a heavy burden in terms of health care resources. Future decision-making policies require consistent data on the management and prognosis of the older patients (> 70 years old) with COVID-19 admitted in the intensive care unit (ICU).

Methods: Characteristics, management, and prognosis of critically ill old patients (> 70 years) were extracted from the international prospective COVID-ICU database. A propensity score weighted-comparison evaluated the impact of intubation upon admission on Day-90 mortality.

Results: The analysis included 1199 (28% of the COVID-ICU cohort) patients (median [interquartile] age 74 [72–78] years). Fifty-three percent, 31%, and 16% were 70–74, 75–79, and over 80 years old, respectively. The most frequent comorbidities were chronic hypertension (62%), diabetes (30%), and chronic respiratory disease (25%). Median Clinical Frailty Scale was 3 (2–3). Upon admission, the PaO₂/FiO₂ ratio was 154 (105–222). 740 (62%) patients were intubated on Day-1 and eventually 938 (78%) during their ICU stay. Overall Day-90 mortality was 46% and reached 67% among the 193 patients over 80 years old. Mortality was higher in older patients, diabetics, and those with a lower PaO₂/FiO₂ ratio upon admission, cardiovascular dysfunction, and a shorter time between first symptoms and ICU admission. In propensity analysis, early intubation at ICU admission was associated with a significantly higher Day-90 mortality (42% vs 28%; hazard ratio 1.68; 95% CI 1.24–2.27; *p* < 0.001).

Conclusion: Patients over 70 years old represented more than a quarter of the COVID-19 population admitted in the participating ICUs during the first wave. Day-90 mortality was 46%, with dismal outcomes reported for patients older than 80 years or those intubated upon ICU admission.

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Keywords: Acute respiratory distress syndrome, Intubation, COVID-19, Mortality, Old patients, Intensive care unit, Frailty

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a risk factor for acute respiratory distress syndrome (ARDS) that is currently a major health-care challenge worldwide. The prognosis of this disease widely varies between countries, the age of the patients, the characteristics of the population studied, and the severity of the ARDS [1]. Then, the case fatality rates observed in ARDS-related SARS-CoV-2 is close to 30–40% [2–4], but can reach 70% in the older patients [5–7]. Given the heavy burden of ARDS-related SARS-CoV-2 infection in terms of health care resources and the worrisome prognosis of this disease, the pandemic has raised several ethical questions. One of them is the decision to admit the oldest patients in the ICU [8], which should be guided by robust data on the outcomes of that population. Therefore, there is an urgent need to provide consistent data on the management and prognosis of the elderly patients in the intensive care unit (ICU) [9]. These data may serve policymakers to properly and fairly allocate health care resources to that population and also to provide transparent information to the patient and caregivers. To date, few studies specifically reported the management and prognosis of the elderly patients in the context of SARS-CoV-2 lower respiratory tract infection [10, 11], but none were focused on a population admitted in ICU. In a large German study enrolling 10,021 patients, 923 (9%) patients over 70 years old received ventilatory support which was associated with 63% in-hospital mortality in those 70–79 years [4]. This result concurred with the dismal prognosis reported in previous studies focused on elderly patients with ARDS not related to SARS-CoV-2 infection [12, 13]. As the debate is still active whether the management of COVID-19 should differ from ARDS related to other causes [14], the specific ICU management and outcomes of the old patients with SARS-CoV-2 related ARDS has not been fully described so far. We sought to assess the characteristics, management, and prognosis of the patients over 70 years enrolled in the international COVID-ICU cohort [15].

Methods

Study design, patients

We performed an ancillary analysis of the COVID-ICU study. COVID-ICU was a multi-center, observational, and prospective cohort study conducted in 149

ICUs from 138 centers, across three countries (France, Switzerland, and Belgium) and has been described elsewhere [15]. It received approval from the ethical committee of the French Intensive Care Society (CE-SRLF 20-23) and Swiss and Belgium ethical committees following local regulations. All patients or close relatives were informed that their medical data were anonymously included in the COVID-ICU cohort. Patients and relatives had the possibility not to participate in the study. In case of refusal, the data were not collected accordingly. This manuscript follows the STROBE statement for reporting cohort studies.

For this analysis, we restricted the study population to patients who were 70 and above 70 years of age at the time of the admission to the participating ICU between February 25, 2020, and May 4, 2020, with laboratory-confirmed SARS-CoV-2 infection, and available Day-90 vital status. Laboratory confirmation for SARS-Cov-2 was defined as a positive result of real-time reverse transcriptase-polymerase chain reaction (RT-PCR) assay from either nasal or pharyngeal swabs, or lower respiratory tract aspirates [16].

Data collection

Full description of data collection is provided in the Additional file 1. Baseline information collected at ICU admission were: age, sex, body mass index (BMI), active smoking, Simplified Acute Physiology Score (SAPS) II score [17], worse Sequential Organ Failure Assessment (SOFA) [18] during the first 24 h, comorbidities, immunodeficiency (if present), Clinical Frailty Scale [19], the date of the first symptom, and dates of the hospital and ICU admissions. The Clinical Frailty Scale was collected upon ICU admission by the physician in charge of the patient during the medical examination. If the patient was not able to communicate, the physician obtained the information from the relatives. The Clinical Frailty Scale is an ordinal hierarchical scale of 9 ranks, with a score of 1 being very fit, 2 well, 3 managing well, 4 vulnerable, 5 mildly frail, 6 moderately frail, 7 severely frail, 8 very severely frail, and 9 terminally ill. We also collected modes of ventilation and oxygenation and complications over the ICU stay. Patient outcomes included duration of mechanical ventilation, vital status at ICU and hospital discharge, and 28, 60, and 90 days after ICU admission. Lastly, life-sustaining treatment decisions were also collected.

Statistical analyses

Characteristics of patients were described as frequencies and percentages for categorical variables, whereas continuous variables were reported as mean and standard deviation or median and interquartile range. Categorical variables were compared by Chi-square or Fisher's exact test, and continuous variables were compared by Student's *t*-test or Wilcoxon's rank-sum test. Kaplan–Meier overall survival curves until Day-90 were computed, and were compared using log-rank tests. Detailed statistical analysis is provided in the Additional file 1.

Baseline risk factors of death at Day-90 were assessed using univariate and multivariate Cox regression model stratified on the center variable. Proportional hazard assumption was assessed by inspecting the scaled Schoenfeld residuals and Harrell's test [20]. To assess invasive mechanical ventilation effect on Day-90 mortality, we used a Cox proportional hazard model weighted on inverse probability of treatment weighting (IPTW) using propensity score (PS) defined as the predictive probability of invasive mechanical ventilation conditional on measured baseline covariates [21]. A multivariate logistic regression model was performed to estimate the PS for each patient in that population. To assess the balance of measured covariates between treatment groups, we used the standardized mean differences before and after PS weighting [22]. Then, a Cox proportional hazard model weighted on IPTW was performed to estimate the average treatment effect in the entire eligible population [21]. Hazard ratio and its 95% confidence interval were then estimated for the Day-90 mortality associated with invasive mechanical ventilation at Day-1. This analysis was performed on the complete cases data set, and a sensitivity analysis was performed using multiple imputations due to missing data.

All analyses were performed at a two-sided α level of 5% and conducted with R version 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Characteristics of patients at ICU admission

From the 4244 patients enrolled in the COVID-ICU dataset, 1199 (28%) (1115, 41, 43 patients in France, Switzerland, and Belgium, respectively) met the inclusion criteria of the present study (i.e., age over 70 years old) (see the Additional file 1: Figure S1). The main descriptors of the patient's characteristics are presented in Table 1. The median (IQR) age was 74 (72–78) years. Fifty-three percent of the patients were 70–74 years old, 31% were 75–79 years old and 16% were over 80 years old. The majority of the patients were male (73%). The most frequent comorbidities were chronic hypertension (62%),

diabetes (30%), and chronic respiratory disease (25%). Noticeably, the median (IQR) Clinical Frailty Scale was 3 (2–3), with only 160/1085 (15%) vulnerable patients (i.e., Clinical Frailty Scale 4), and 99/1085 (9%) frail patients (i.e., Clinical Frailty Scale 5–9). The time between first symptoms and ICU admission was 8 (6–12) days. SAPS II and SOFA scores at ICU admission were 43 (35–54) and 5 (3–8), respectively.

Mortality was 41%, 45%, and 46% at Day-28, Day-60, and Day-90, respectively (Additional file 1: Table S1). Mortality at Day-90 increased with the age and the Clinical Frailty Scale (Fig. 1). Indeed, Day-90 mortality increased from 39% in the patients between 70 and 74 years to 47% and 67% in the groups of patients between 75 and 79 years and those over 80 years old, respectively ($p < 0.001$) (Fig. 2a). Similarly, mortality at Day-90 was 40%, 61%, and 71% in the patients' groups with Clinical Frailty Scale from 1–3; 4; and ≥ 5 , respectively ($p < 0.001$) (Fig. 2b). The mortality was also higher in patients intubated during their ICU stay ranging from 44 to 74% (Additional file 1: Figure S2). Of note, during the period of the first 14 days following the ICU admission, 253/1,199 (21%) of the patients had a life-sustaining treatment limitation decision, whom 223 (88%) died at day 90 (207 (82%) while in the ICU).

Predictive factors of mortality at Day-90

Results of the multivariable analysis are reported in Table 2. Because of multicollinearity observed between age and Clinical Frailty Scale, invasive mechanical ventilation at Day-1 and $\text{PaO}_2/\text{FiO}_2$ ratio, renal replacement therapy and the renal component of the SOFA, only Clinical Frailty Scale, $\text{PaO}_2/\text{FiO}_2$ ratio, and the renal component of the SOFA were retained in the model. Day-1 patients' characteristics significantly associated with a higher 90-Day mortality rate identified by the Cox regression model after center stratification were older age, diabetes, higher cardiovascular component of the SOFA score, lower $\text{PaO}_2/\text{FiO}_2$, and a shorter time between first symptoms and ICU admission (Table 2). The same analysis re-run of missing after multiple imputations data (Additional file 1: Table S2) yielded similar conclusions. Interestingly, being admitted to the ICU after March 29 was also associated with a better outcome (Additional file 1: Figure S3). Kaplan–Meier survival estimates according to age categories, Clinical Frailty Scale, and $\text{PaO}_2/\text{FiO}_2$ ratio at Day-1 of ICU admission are provided in Fig. 2.

Propensity score analysis

Six hundred and forty-four patients had a cardiovascular component of the SOFA < 2 , comprising 425 patients intubated on Day-1 and 219 initially treated without

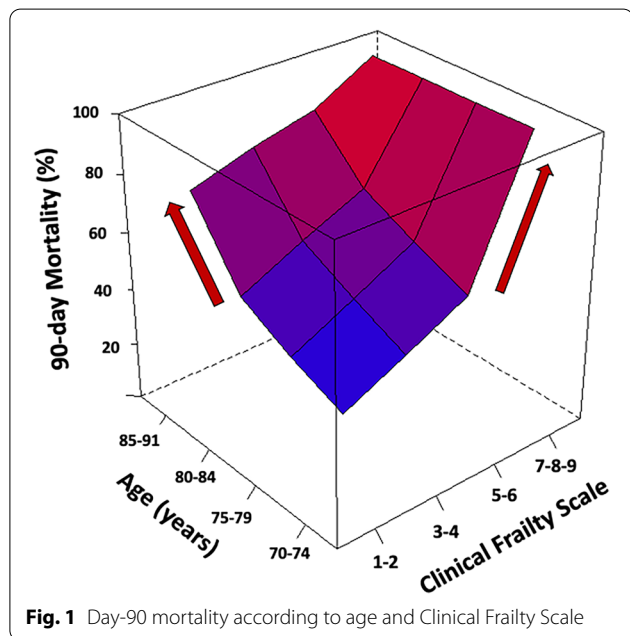
Table 1 Demographic characteristics and management during the first 14 days of ICU according to their Day-90 survival status

	All patients n=1199	Day-90 status		P value
		Alive n=650	Death n=549	
Age, years	74 (72–78)	73 (71–77)	75 (72–79)	< 0.001
70–74	639 (53)	392 (60)	247 (45)	
75–79	367 (31)	194 (30)	173 (32)	
> 80	193 (16)	64 (9)	129 (24)	
Body mass index, kg m ⁻²	27 (25–31)	27 (25–31)	27 (25–30)	0.452
Female gender	326 (27)	177 (27)	149 (27)	0.989
Living place				0.007
Home residency	1136 (95)	624 (96)	512 (94)	
Rehabilitation	14 (1)	5 (1)	9 (2)	
Retirement home	20 (2)	4 (1)	16 (3)	
Other	29 (2)	17 (2)	12 (2)	
Comorbidities				
Hypertension	742 (62)	399 (62)	343 (63)	0.728
Diabetes	355 (30)	160 (25)	195 (36)	< 0.001
Active smokers	46 (4)	21 (3)	25 (5)	0.201
Chronic respiratory disease	297 (25)	156 (24)	141 (26)	0.472
Chronic cardiac disease	87 (8)	34 (5)	53 (10)	0.003
Chronic renal insufficiency	108 (9)	44 (7)	64 (12)	0.003
Immunosuppression	99 (8)	45 (7)	54 (10)	0.062
Clinical Frailty Scale	3 (2–3)	3 (2–3)	3 (2–4)	< 0.001
1–3	826 (76)	498 (85)	328 (66)	
4	160 (15)	62 (11)	98 (20)	
5–9	99 (9)	29 (5)	70 (14)	
ICU admission				
Time between hospital and ICU admission, days	1 (0–3)	1 (0–3)	0 (0–2)	0.066
Time between first signs and ICU admission, days	8 (6–12)	10 (6–13)	7 (5–10)	< 0.001
SAPS II	43 (35–54)	41 (33–51)	47 (38–57)	< 0.001
SOFA score	5 (3–8)	4 (3–8)	6 (4–9)	< 0.001
Renal component	0 (0–1)	0 (0–0)	0 (0–1)	< 0.001
Cardiovascular component	1 (0–4)	0 (0–3)	3 (0–4)	< 0.001
During the first 24 hours in the ICU				
PaO ₂ /FiO ₂ ratio	154 (105–222)	167 (115–224)	139 (94–212)	0.004
Standard oxygen	339 (29)	210 (33)	129 (24)	< 0.001
Flow, L/min	9 (6–15)	7 (5–15)	12 (7–15)	< 0.001
High-flow oxygen therapy	249 (21)	150 (24)	99 (18)	0.025
Flow, L/min	50 (40–60)	50 (40–60)	50 (40–50)	0.295
FiO ₂ , %	75 (60–94)	70 (60–85)	90 (70–100)	< 0.001
Invasive mechanical ventilation	740 (62)	350 (54)	390 (71)	< 0.001
Prone positioning	146 (20)	61 (18)	85 (22)	0.172
Continuous neuromuscular blockades	517 (43)	251 (39)	266 (48)	0.383
During the first 14 days in the ICU				
High-flow oxygen therapy	331 (28)	208 (32)	123 (23)	0.002
Invasive mechanical ventilation	936 (78)	461 (71)	475 (87)	< 0.001
Prone positioning	613 (51)	274 (42)	339 (62)	0.001
Continuous neuromuscular blockades	803 (67)	390 (60)	413 (75)	0.165
Renal replacement therapy	231 (19)	84 (13)	147 (26)	< 0.001
Corticosteroids	409 (34)	191 (30)	218 (40)	< 0.001
Life sustaining treatment decision	253 (21)	30 (5)	223 (41)	< 0.001

Table 1 (continued)

Values are expressed as median (interquartile range) or *n* (%)

ICU intensive care unit, SAPS simplified acute physiology score, SOFA Sequential Organ Failure Assessment



invasive mechanical ventilation. These two groups differed in several respects (Additional file 1: Table S3). Patients intubated on Day-1 had a higher SOFA cardiovascular component and were more likely admitted to the ICU before March 28. Interestingly, their Clinical Frailty Scale, their BMI, the time between first symptoms and ICU admission, and the PaO₂/FiO₂ ratio were not different. After weighting on the Inverse Probability

Weighting Treatment using propensity score estimated in 269 patients with no missing values, 123 non-intubated patients were compared to 146 patients intubated at Day-1 with a similar medical history and initial severity (Additional file 1: Table S3). We found a significantly different Day-90 mortality (28% in the non-intubated group vs. 42% in the intubated group; HR 1.68; 95% CI 1.24–2.27; *p* < 0.001) (Fig. 3). A similar analysis performed after multiple imputations of missing data (i.e., 644 patients) yielded similar conclusions (HR 1.33; 95% CI 1.11–1.59; *p* = 0.002).

Discussion

Herein, we report the characteristics, management, and outcomes of a large prospective cohort of old critically ill patients during the first wave of the COVID-19 outbreak. Patients over 70 years represented 28% of the COVID-19 population admitted during that period of 8 weeks in the participating ICUs. Their overall Day-90 mortality was 46%, which increased with the age and the Clinical Frailty Scale and reached 67% for the patients over 80 years. Older age, diabetes, a longer time between first symptoms and ICU admission, a SOFA cardiovascular component ≥ 3, a lower PaO₂/FiO₂ ratio, and being admitted to the ICU during the first month of the pandemic were independent risk factors of Day-90 mortality. Noticeably, our propensity score analysis suggests that an early invasive mechanical ventilation strategy seemed associated with a worse prognosis in that population.

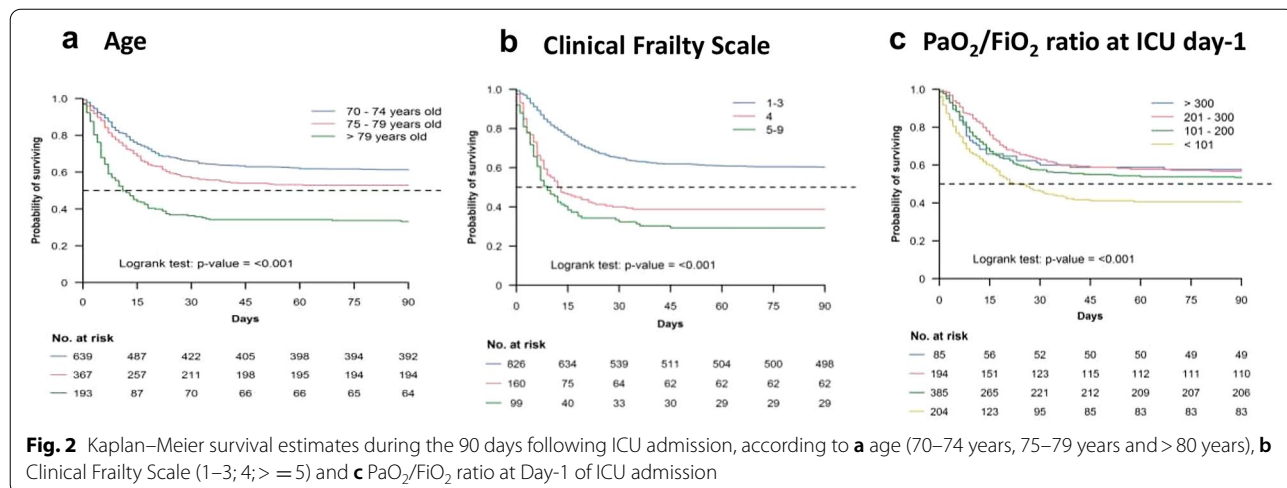


Table 2 Predictive patient factors associated with Day-90 mortality in critically ill patients older than 70 years old with COVID-19 stratified on the center variable

	No.	Univariate HR (95% CI)	P value	Multivariate HR (95% CI)	P value
Age, years	1199	–	< 0.001	–	
70–75		–		–	
75–79		1.32 (1.08–1.60)		–	
80–84		2.09 (1.64–2.68)		–	
85–91		4.09 (2.97–5.65)		–	
Clinical Frailty Scale	1085	–	< 0.001	–	< 0.001
1–3		–		–	
4		2.14 (1.71–2.68)		2.24 (1.63–3.09)	
5–9		2.81 (2.17–3.64)		2.83 (1.96–4.08)	
Body mass index, kg/m ²	1096		0.435	–	0.103
< 25		–		–	
25–29		0.96 (0.77–1.20)		1.10 (0.83–1.48)	
30–34		0.85 (0.64–1.11)		0.78 (0.55–1.12)	
35–39		0.89 (0.61–1.31)		0.90 (0.53–1.51)	
≥ 40		1.33 (0.83–2.13)		1.26 (0.72–2.22)	
Diabetes	1184	1.43 (1.20–1.71)	< 0.001	1.42 (1.10–1.82)	0.043
Hypertension	1189	1.03 (0.87–1.23)	0.726	0.87 (0.68–1.12)	0.697
Immunodepression	1186	1.31 (0.99–1.74)	0.066	0.97 (0.63–1.48)	0.298
Time between first signs and ICU admission	1109		< 0.001		0.003
< 4 days		–		–	
4–7 days		0.88 (0.70–1.12)		0.87 (0.63–1.18)	
≥ 8 days		0.50 (0.40–0.64)		0.61 (0.44–0.84)	
SOFA Cardiovascular component ≥ 3	1160	1.74 (1.47–2.07)	< 0.001	2.13 (1.66–2.74)	< 0.001
SOFA renal component ≥ 3	1140	1.84 (1.37–2.49)	< 0.001	1.39 (0.94–2.05)	0.909
Invasive mechanical ventilation at Day-1	1199	1.66 (1.38–1.99)	< 0.001	–	
Renal replacement therapy at Day-1	1188	2.50 (1.67–3.73)	< 0.001	–	
ICU admission after March 29 th	1199	0.67 (0.56–0.80)	< 0.001	0.70 (0.55–0.89)	< 0.001
PaO ₂ /FiO ₂ ratio	868		< 0.001	–	0.001
200 < PaO ₂ /FiO ₂		–		–	
100 < PaO ₂ /FiO ₂ ≤ 200		1.14 (0.90–1.44)		1.28 (0.97–1.69)	
PaO ₂ /FiO ₂ ≤ 100		1.68 (1.30–2.16)		2.35 (1.73–3.19)	

Age, invasive mechanical ventilation and renal replacement therapy variables were excluded from multivariate analysis for multicollinearity issue
CI confidence interval, *HR* hazard ratio, *ICU* intensive care unit, *SOFA* Sequential Organ Failure Assessment

The mortality of elderly patients admitted in the ICU for SARS-Cov-2-related ARDS varied from 77 to 84% [1]. These mortality rates appear very high compared to those reported in ARDS outside COVID-19 [12, 23]. For instance, the Large Observational Study to Understand the Global Impact of Severe Acute Respiratory Failure (LUNG SAFE) reported Day-90 mortality rates of 47%, 51%, and 50% for the 70–74 years, 75–79, and > 80 years old patients, respectively (unpublished data, personal communication from the authors) [24]. Our Day-90 mortality (46%) contrasts with early reports (1–3) and the large German cohort of 10,021 patients (923 patients over 70 years) [4] despite a large proportion of patients

intubated during their ICU stay in our study (78%). It was, however much higher than the 25% Day-90 mortality observed in the rest of the population of the COVID-ICU cohort (i.e., patients < 70 years old) [15]. Besides, the mortality of our patients over 80 years old seems higher when compared with same-age patients with non-COVID-19-related ARDS, planned [25], or unplanned ICU admission [26]. Several factors such as triage policy before ICU admission, ICU resources at the time of the pandemic, ICU case volume [27] and patients' comorbidities may explain these discrepancies.

Before the context of COVID-19, frailty as measured with the Clinical Frailty Scale in elderly critically

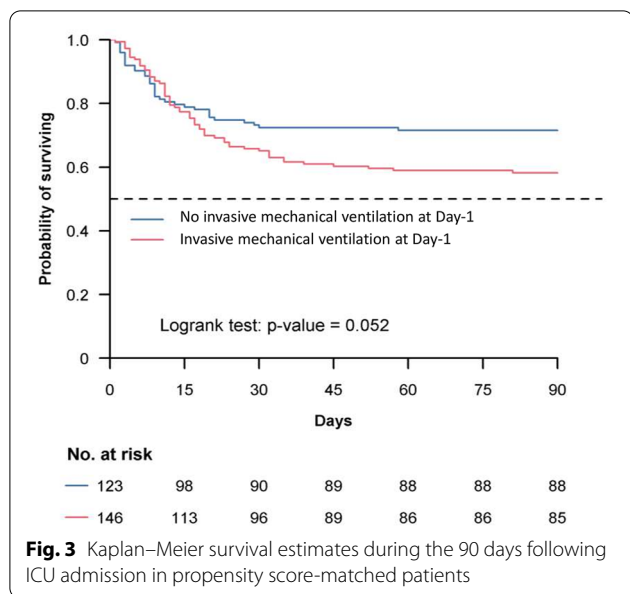


Fig. 3 Kaplan–Meier survival estimates during the 90 days following ICU admission in propensity score-matched patients

ill patients was strongly associated with Day-30 mortality [26]. This tool was even a better predictor of mortality than SOFA score [25] or classical geriatric scales [26]. Recently, in a large observational study performed in the United Kingdom that enrolled 1564 COVID-19 patients with a median age of 74 years, and more than 50% of the population with a Clinical Frailty Scale >4, the crude hazard ratio (95% confidence interval) for mortality were 3.12 (2.05–4.76) and 4.41 (2.90–6.71) for those with a Clinical Frailty Scale of 5–6 and 7 to 9, respectively [11]. However, the overall low Clinical Frailty Scale reported in our study and our low proportion of vulnerable or frail patients suggest that a significant triage was performed before ICU admission [28]. No national ICU admission criteria policy was provided at the time of the study, and the ICU admission decision was left to the discretion of the physicians in charge of the patient. Whether this triage resulted from intensivist’s evaluation, non-intensivists practitioner’s judgment, ICU beds occupancy, or the patients themselves should be further investigated.

Old patients admitted to the ICU with COVID-19 are at increased risk of death [3, 29] and the decision of ICU admission can be challenging [8]. The use of the Clinical Frailty Scale has proven to be helpful in this context [9]. Besides, the respect of the patient’s wishes and values, expressed directly by the patient via advance directives or reported by the healthcare surrogate should have to be taken into consideration [30]. In old patients with an uncertain prognosis, it can be particularly difficult to decide whether or not to admit to the ICU and provide invasive treatments such as mechanical ventilation. In such circumstances, an “ICU-trial of limited-time” has

been proposed [31]. However, in the context of COVID-19, this strategy could be challenging as a long invasive mechanical duration is often required to see any clinical improvement. In other words, an ICU trial with a too-short limited-time could lead to misinterpretation and ethical misconduct. This important point is reinforced by the extremely long durations of invasive mechanical ventilation, and ICU length of stay observed in our surviving patients.

Beyond the admission of elderly patients in the ICU, the decision of the timing of intubation remains crucial. The majority of our patients (62%) were intubated on ICU Day-1. Interestingly, apart from obvious reasons such as hemodynamic instability, relevant clinical differences were scarce between patients who were intubated upon admission and those who were not. For instance, their Clinical Frailty Scale, time between first symptoms and ICU admission, and PaO₂/FiO₂ ratio were not significantly different, suggesting that the decision of intubation on admission was mainly driven by the experience of the physicians and the limited knowledge of this new disease at that time. As reported by others [32], the proportion of patients being intubated upon ICU admission during the first period of the study decreased from 67 to 56% during the last month (after March 29th, 2020), with being admitted in that latter period independently associated with a lower Day-90 mortality. An early intubation strategy was even associated with a poorer outcome in our matching analysis while further studies are warranted to confirm this finding. Less reluctance of the caregivers to provide non-invasive oxygen strategies along the first COVID-19 wave has been reported [15], but the benefit in terms of survival is still uncertain [33]. These strategies seem promising in that at-risk population where patients receiving invasive mechanical ventilation are more likely to experience long-term physical, neuropsychiatric, and quality of life impairments [34, 35].

Our study is a large international cohort of old critically ill patients with detailed characteristics and Day-90 outcome. However, despite a large number of participating ICUs, our population sample may be prone to selection biases that may limit generalizability. Since the study was mainly conducted in France (1115, 41 and 43 patients in France, Switzerland, and Belgium, respectively) during a period with high pressure on the health system and before the publication of several core randomized trials [36, 37], our findings may differ during subsequent COVID-19 outbreaks, and in countries with different public health care organizations, ICU admission policy, or ICU resources [4]. Comparison with further studies from other countries will help to better allocate health care resources and determine the indications and contraindications of non-invasive ventilatory strategies in this

specific population. Besides, we only provided data on patients who were admitted to the ICU, and no information was available on treatments before ICU admission nor on patients for whom an ICU admission was denied in the participating ICUs. Besides, important detailed information is also lacking regarding therapy limitations. This information would have allowed a thorough investigation of ICU-admission criteria used during this surge of ICU resources.

Conclusions

During the first COVID-19 pandemic wave, patients over 70 years old represented more than a quarter of the COVID-19 population in the participating ICUs of that study. Their overall Day-90 mortality was 46% with a dismal prognosis in patients older than 80 years old. Given the very long duration of mechanical ventilation as well as a prolonged ICU and hospital stay in the survivors, further studies are urgently warranted to evaluate the long-term psychological, neurocognitive, and functional outcomes of this high-risk and vulnerable population.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s13613-021-00861-1>.

Additional file 1. Detailed description of the data collection and statistical analysis and complementary tables and figures

Acknowledgements

The authors are particularly grateful to all caregivers, COVID-ICU investigators and patients who have been involved in the study. Participating sites and COVID-ICU investigators: CHU Angers, Angers, France (Alain Mercat, Pierre Asfar, François Beloncle, Julien Demiselle), APHP—Hôpital Bicêtre, Le Kremlin-Bicêtre, France (Tài Pham, Arthur Pavot, Xavier Monnet, Christian Richard), APHP—Hôpital Pitié Salpêtrière, Paris, France (Alexandre Demoule, Martin Dres, Julien Mayaux, Alexandra Beurton), CHU Caen Normandie—Hôpital Côte de Nacre, Caen, France (Cédric Daubin, Richard Descamps, Aurélie Joret, Damien Du Cheyron), APHP—Hôpital Cochin, Paris, France (Frédéric Pene, Jean-Daniel Chiche, Mathieu Jozwiak, Paul Jaubert), APHP—Hôpital Tenon, Paris (France, Guillaume Voiriot, Muriel Fartoukh, Marion Teulier, Clarisse Blayau), CHRU de Brest—La Cavale Blanche, Brest, France (Erwen L'Her, Cécile Aubron, Laetitia Bodenès, Nicolas Ferrière), Centre Hospitalier de Cholet, Cholet, France (Johann Auchabie, Anthony Le Meur, Sylvain Pignal, Thierry Mazzoni), CHU Dijon Bourgogne, Dijon, France (Jean-Pierre Quenot, Pascal Andreu, Jean-Baptiste Roudau, Marie Labruyère), CHU Lille—Hôpital Roger Salengro, Lille, France (Saad Nseir, Sébastien Preau, Julien Poissy, Daniel Mathieu), Groupe Hospitalier Nord Essonne, Longjumeau, France (Sarah Benhamida, Rémi Paulet, Nicolas Roucaud, Martial Thyrault), APHM—Hopital Nord, Marseille, France (Florence Daviet, Sami Hraiech, Gabriel Parzy, Aude Sylvestre), Hôpital de Melun-Sénart, Melun, France (Sébastien Jochmans, Anne-Laure Bouilland, Mehran Monchi), Élément Militaire de Réanimation du SSA, Mulhouse, France (Marc Danguy des Déserts, Quentin Mathais, Gwendoline Rager, Pierre Pasquier), CHU Nantes—Hôpital Hotel Dieu, Nantes, France (Reignier Jean, Seguin Amélie, Garret Charlotte, Canet Emmanuel), CHU Nice—Hôpital Archet, Nice, France (Jean Dellamonica, Clément Saccheri, Romain Lombardi, Yanis Kouchit), Centre Hospitalier d'Orléans, Orléans, France (Sophie Jacquier, Armelle Mathonnet, Mai-AhnNay, Isabelle Runge), Centre Hospitalier Universitaire de la Guadeloupe, Pointe-à-Pitre, France (Frédéric Martino, Laure Flurin, Amélie Rolle, Michel Carles), Hôpital de la Milétrie, Poitiers, France (Rémi Coudroy, Arnaud W Thille, Jean-Pierre Frat, Maeva

Rodriguez), Centre Hospitalier Roanne, Roanne, France (Pascal Beuret, Audrey Tientcheu, Arthur Vincent, Florian Michelin), CHU Rouen—Hôpital Charles Nicolle, Rouen, France (Marie Anne Melone, Maxime Gauzi, Arnaud Guilbert, Geoffrey Kouadri), CHRU Tours—Hôpital Bretonneau, Tours, France (Valérie Gissot, Stéphane Ehrmann, Charlotte Salmon Gandonnière, Djilali Elaroussi), Centre Hospitalier Bretagne Atlantique, Vannes, France (Agathe Delbove, Yannick Fedun, Julien Huntzinger, Eddy Lebas), CHU Liège, Liège, Belgique (Grâce Kisoka, Céline Grégoire, Stella Marchetta, Bernard Lambermont), Hospices Civils de Lyon—Hôpital Edouard Herriot, Lyon, France (Laurent Argaud, Thomas Baudry, Pierre-Jean Bertrand, Auguste Dargent), Centre Hospitalier Du Mans, Le Mans, France (Christophe Guitton, Nicolas Chudeau, Mickaël Landais, Cédric Darreau), Centre Hospitalier de Versailles, Le Chesnay, France (Alexis Ferre, Antoine Gros, Guillaume Lacave, Fabrice Bruneel), Hôpital Foch, Suresnes, France (Mathilde Neuville, Jérôme Devaquet, Guillaume Tachon, Richard Gallot), Hôpital Claude Galien, Quincy sous Senart, France (Riad Chelha, Arnaud Galbois, Anne Jallot, Ludivine Chalumeau Lemoine), GHR Mulhouse Sud-Alsace, Mulhouse, France (Khaloud Kuteifan, Valentin Pointurier, Louise-Marie Jandeaux, Joy Mootien), APHP—Hôpital Antoine Bécclère, Clamart, France (Charles Damoiseil, Benjamin Sztrymf), APHP—Hôpital Pitié-Salpêtrière, Paris, France (Matthieu Schmidt, Alain Combes, Juliette Chommeloux, Charles Edouard Luyt), Hôpital Intercommunal de Créteil, Créteil, France (Frédérique Schortgen, Leon Rusel, Camille JUNG), Hospices Civils de Lyon—Hôpital Neurologique, Lyon, France (Florent Gobert), APHP—Hôpital Necker, Paris, France (Damien Vimperc, Lionel Lamhaut), Centre Hospitalier Public du Cotentin—Hôpital Pasteur, Cherbourg-en-cotentin, France (Bertrand Sauneuf, Liliane Charrier, Julien Calus, Isabelle Desmeules), CHU Rennes—Hôpital du Pontchaillou, Rennes, France (Benoît Painvin, Jean-Marc Tadie), 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Fontainebleau, France (Nicolas Robin, Alexandre Ouali, Lucie Houdou), Hôpital Universitaire de Genève, Genève, Suisse (Christophe Le Terrier, Noémie Suh, Steve Primmaz, Jérôme Pugin), AHP—Hôpital Beaujon, Clichy, France (Emmanuel Weiss, Tobias Gauss, Jean-Denis Moyer, Catherine Paugamburtz), Groupe Hospitalier Bretagne Sud, Lorient, France (Béatrice La Combe, Rolland Smonig, Jade Violleau, Pauline Cailliez), Centre Hospitalier Intercommunal Toulon, La Seyne sur Mer, France (Jonathan Chelly), Centre Hospitalier de Dieppe, Dieppe, France (Antoine Marchalot, Cécile Saladin, Christelle Bigot), CHU de Martinique, Fort-de-France, France (Pierre-Marie Fayolle, Jules Fatséas, Amr Ibrahim, Dabor Resiere), Hôpital Fondation Adolphe de Rothchild, Paris, France (Rabih Hage, Clémentine Cholet, Marie Cantier, Pierre Trouiller), AHP—Bichat Claude Bernard, Paris, France (Philippe Montravers, Brice Lortat-Jacob, Sebastien Tanaka, Alexy Tran Dinh), AHP—Hôpital Universitaire Paris Sud, Bicêtre, France (Jacques Duranteau, Anatole Harrois, Guillaume Dubreuil, Marie Werner), AHP—Hôpital Européen Georges Pompidou, Paris, France (Anne Godier, Sophie Hamada, Diane Zlotnik, Hélène Nougue), AHP, GHU Henri Mondor, Créteil, France (Armand Mekontso-Dessap, Guillaume Carteaux, Keyvan Razazi, Nicolas De Prost), AHP—Hôpitaux Universitaires Henri Mondor, Créteil, France (Nicolas Mongardon, Olivier Langeron, Eric Levesque, Arié Attias), AHP—Hôpital Lariboisière, Paris, France (Charles de Roquetaillade, Benjamin G. 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Hazera), AHP—Hôpital Pitié Salpêtrière, Paris, France (Anne-Lyse Masse, Suela Demiri, Corinne Vezinet, Elodie Baron, Deborah Benchetrit, Antoine Monsel), Clinique du Val d'Or, Saint Cloud, France (Grégoire Trebbia, Emmanuelle Schaack, Raphaël Lepecq, Mathieu Bobet), Centre Hospitalier de Béthune, Béthune, France (Christophe Vinsonneau, Thibault Dekeyser, Quentin Delforge, Imen Rahmani), Groupe Hospitalier Intercommunal de la Haute-Saône, Vesoul, France (Bérenghère Vivet, Jonathan Paillot, Lucie Hierle, Claire Chaignat, Sarah Valette), Clinique Saint-Martin, Caen, France (BenoîtHer, Jennifer Brunet), Ramsay Générale de Santé, Clinique Convert, Bourg en Bresse, France (Mathieu Page, Fabienne Boiste, Anthony Collin), Hôpital Victor Jousselin, Dreux, France (Florent Bavozet, Aude Garin, Mohamed Dlala, KaisMhamdi), Centre Hospitalier de Troye, Troye, France, (Bassem Beilouny, Alexandra Lavalard, Severine Perez), CHU de ROUEN—Hôpital Charles Nicolle, Rouen, France (Benoit Veber, Pierre-Gildas Guitard, Philippe Gouin, Anna Lamacz), Centre Hospitalier Agen-Nérac, Agen, France (Fabienne Plouvier, Bertrand P delaborde, AïssaKherchache, Amina Chaalal), AHP—Hôpital Louis Mourier, Colombes, France (Jean-Damien Ricard, Marc Amouretti, Santiago Freitas-Ramos, Damien Roux), AHP—Hôpital Pitié-Salpêtrière, Paris, France (Jean-Michel Constantin, Mona Assefi, Marine Lecore, Agathe Selves), Institut Mutualiste Montsouris, Paris, France (Florian Prevost, Christian Lamer, Ruiying Shi, Lyes Knani), CHU Besançon—Hôpital Jean Minjot, Besançon, France, (Sébastien PiliFloury, Lucie Vettoretti), AHP—Hôpital Universitaire Robert-Debré, Paris, France (Michael Levy, Lucile Marsac, Stéphane Dauger, Sophie Guilmin-Crépon), CHU Besançon—Hôpital Jean Minjot, Besançon, France, (Hadrien Winiszewski, Gael Piton, Thibaud Soumagne, Gilles Capellier); Médipôle Lyon-Villeurbanne, Villeurbanne, France, (Jean-Baptiste Putegnat, Frédérique Bayle, Maya Perrou, Ghyslaine Thao), AHP—Ambroise Paré, Boulogne-Billancourt, France (Guillaume Géri, Cyril Charron, Xavier Repessé, Antoine Vieillard-Baron), CHU Amiens Picardie, Amiens, France (Mathieu Guilbart, Pierre-Alexandre Roger, Sébastien Hinard, Pierre-Yves Macq), Hôpital Nord-Ouest, Villefranche-sur-Saône, France (Kevin Chaulier, Sylvie Goutte), CH de Châlons en Champagne, Châlons en Champagne, France (Patrick Chillet, Anaïs Pitta, Barbara Darjent, Amandine Bruneau), CHU Angers, Angers, France (Sigismond Lasocki, Maxime Leger, Soizic Gergaud, Pierre Lemarie), CHU Grenoble Alpes, Grenoble, France (Nicolas Terzi, Carole Schwebel, Anaïs Dartevel, Louis-Marie Galerneau), AHP—Hôpital Européen Georges Pompidou, Paris, France (Jean-Luc Diehl, Caroline Haou-Berlemont, Nicolas Péron, Emmanuel Guérot), Hôpital Privé d'Antony, Antony, France (Abolfazl MohebbiAmoli, Michel Benhamou, Jean-Pierre Deyme, Olivier Andreumont), Institut Arnault Tzanck, Saint Laurent du Var, France (Diane Lena, Julien Cady, Arnaud Causeret, Arnaud De La Chapelle), Centre Hospitalier d'Angoulême, Angoulême, France (Christophe Cracco, Stéphane Rouleau, David Schnell); Centre Hospitalier de Cahors, Cahors, France (Camille Foucault), Centre hospitalier de Carcassonne, Carcassonne, France (Cécile Lory); CHU Nice—Hôpital L'Arche 2, Nice, France (Thibault Chapelle, Vincent Bruckert, Julie Garcia, Abdlazize Sahraoui); Hôpital Privé du Vert Galant, Tremblay-en-France, France (Nathalie Abbosh, Caroline Bornstain, Pierre Pernet); Centre Hospitalier de Rambouillet, Rambouillet, France (Florent Poirson, Ahmed Pasem, Philippe Karoubi); Hopitaux du Léman, Thonon les Bains, France (Virginie Poupinel, Caroline Gauthier, François Bouniol, Philippe Feuchere), Centre Hospitalier Victor Jousselin, Dreux, France (Florent Bavozet, Anne Heron), Hôpital Sainte Camille, Brie sur Marne, France (Serge Carreira, Malo Emery, Anne Sophie Le Floch, Luana Giovannangeli), Hôpital d'Instruction des armées Clermont-Tonnerre, Brest, France (Nicolas Herzog, Christophe Giacardi, Thibaut Baudic, Chloé Thill), AHP—Hôpital Pitié Salpêtrière, Paris, France (Saïd Lebbah, Jessica Palmyre, Florence Tubach, David Hajage); AHP—Hôpital Avicenne, Bobigny, France (Nicolas Bonnet, Nathan Ebstein, Stéphane Gaudry, Yves Cohen); Groupement Hospitalier la Rochelle Ré Amis, La Rochelle, France (Julie Noublanche, Olivier Lesieur); Centre Hospitalier Intercommunal de Mont de Marsan et du Pays des Sources, Mont de Marsan, France (Arnaud Sément, Isabel Roca-Cerezo, Michel Pascal, Nesrine Sma); Centre Hospitalier Départementale de Vendée, La-Roche-Sur-Yon, France (Gwenhaël Colin, Jean-Claude Lacherade, Gauthier Bionz, Natacha Maquigneau); Pôle Anesthésie-Réanimation, CHU Grenoble (Pierre Bouzat, Michel Durand, Marie-Christine Héroult, Jean-François Payen).

Authors' contributions

MD and MS designed the study. MD, MS, AD, AM, AC, SL, AK, TP, GB and DH coordinated the study. MD, AD, CS, EM and TS analyzed the data. MD, MS, DH wrote the manuscript. All authors had full access to all study data, contributed to drafting the manuscript or critical revision of it for important intellectual

content, approved the final version of the manuscript, and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

Funding

This study was funded by the Foundation AP-HP and the Direction de la Recherche Clinique et du Développement and the French Ministry of Health. The REVA network received a 75,000 € research grant from Air Liquide Healthcare. The funder had no role in the design and conduct of the study, collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Human research ethics committee approval for the study was the ethical committee of the French Intensive Care Society (CE-SRLF 20-23) following our local regulations.

Consent for publication

All patients or close relatives were informed that their data were included in the COVID-ICU cohort.

Competing interests

Dr Schmidt reported personal fees from Getinge, Dräger, and Xenios, outside the submitted work. Dr Demoule reports personal fees from Medtronic, grants, personal fees and non-financial support from Philips, personal fees from Baxter, personal fees from Hamilton, personal fees and non-financial support from Fisher & Paykel, grants from French Ministry of Health, personal fees from Getinge, grants and personal fees from Respinor, grants and non-financial support from Lungpacer, outside the submitted work. Dr Dres reported personal fees from Lungpacer. No other disclosures were reported.

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Received: 4 March 2021 Accepted: 24 April 2021

Published online: 14 May 2021

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