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Clinical Predictors of Extended ICU Stay and Their Role in Critical Care Resource Management : A Case-Control Study in Severe Viral Pneumonia

H. BENNANI *, W. ATMANI, M. ABABOU, H. BAKKALI, M. BENSGHIR, N. DOGHMI and H. BALKHI

Department of Anesthesia and intensive care, Mohammed V Military Hospital, Rabat, Morocco.

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Abstract

Background : Efficient use of ICU beds is essential, particularly during outbreaks of severe respiratory disease. Understanding which patients are likely to remain in ICU longer helps improve planning and optimize patient care pathways.

Objective: To identify clinical and epidemiological factors linked to extended ICU stay and explore their impact on resource planning.

Methods : We conducted a case-control study over six months (August 2020 – February 2021) in the ICU of HMMV Hospital.

Adult patients with severe viral pneumonia were included. Demographic data, comorbidities, CT lung involvement, need for mechanical ventilation (MV), and outcomes were analyzed.

Prolonged ICU stay was defined as more than five days. Logistic regression identified independent predictors.

Results: Among 300 patients (mean age 67 ± 11 years; 72.3% men), prolonged ICU stay was strongly associated with obesity (adjusted OR 6.25; 95% CI 2.56–15.3), diabetes (OR 2.55; 95% CI 1.34–4.85), malignancy (OR 4.00; 95% CI 1.14–13.69), and MV (OR 3.38; 95% CI 1.67–6.83).

Conclusion : Obesity, diabetes, malignancy, and mechanical ventilation significantly increase the likelihood of prolonged ICU stay.

These insights may support better bed management, improve resource allocation, and strengthen ICU preparedness for future surges.

Keywords : ICU; Prolonged Stay; Mechanical Ventilation; Obesity; Diabetes; Resource Management

1. Introduction

Severe respiratory infections continue to challenge healthcare systems by creating surges in ICU admissions and straining available resources [1,2].

In such settings, predicting how long patients will require critical care is essential to maintain capacity and ensure timely access for all patients [3].

* Corresponding author: H. BENNANI

Recognizing early which patients are likely to have longer ICU stays can help clinicians and administrators anticipate demand, streamline patient flow, and allocate staff and equipment more efficiently [4]. While much of the literature has focused on mortality and ventilation outcomes [5,6],

less attention has been paid to the predictors of ICU length of stay, even though this factor directly affects resource utilization and hospital operations [7].

The aim of this study was to explore the clinical predictors of extended ICU stay among patients admitted with severe viral pneumonia and to discuss how these findings can contribute to improved ICU management and preparedness strategies.

2. Materials and Methods

- **Study Type, Location, and Period** This was a case-control study conducted in the COVID-19 intensive care unit of HMMV over a 6-month period, from August 2020 to February 2021.
- **Study Sample** The study included patients hospitalized in the intensive care unit for COVID-19 pneumonia, with a diagnosis confirmed by a positive COVID-19 polymerase chain reaction (PCR) test or based on clinical, biological, and radiological findings. These patients met the admission criteria for intensive care and intensive care units as defined by the SFAR (French Society of Anesthesia and Intensive Care Medicine).
- **Data Collection** A medical data sheet was created to collect information from the patients' medical records, which were written by the on-duty physician of the COVID-19 intensive care unit at the time of their admission. The collected data included: age, sex, BMI, diabetes, hypertension (HBP), cardiac pathologies, asthma, COPD, hypothyroidism, neoplastic pathologies, the degree of pulmonary CT scan involvement, recourse to mechanical ventilation (MV), the length of stay in intensive care, and the outcome (survival or death).
- **Variable Definitions** The primary outcome was the length of stay in intensive care. The exposure factors were as follows:
  - **Age:** Two groups (>59 years and <59 years)
  - **Sex:** Male or female
  - **Obesity:** Any patient with a BMI > 30 was considered obese.
  - **Diabetes:** History of diabetes or fasting blood glucose (FBG) > 1.26 measured twice.
  - **Hypertension (HTA):** History of HTA or blood pressure (BP) > 140/90 measured twice after a 15-minute rest interval.
  - **Cardiac pathologies:** All subjects followed for ischemic, arrhythmogenic heart disease, or heart failure.
  - **Asthma:** History of asthma.
  - **COPD:** Cough + expectoration 3 months/year for two consecutive years.
  - **Chronic Renal Failure (CRF):** History of CRF (eGFR < 60 mL/min/1.73 m^2 for more than 3 months).
  - **Neoplastic pathology:** History of neoplastic pathologies.
  - **Hypothyroidism:** History of hypothyroidism.
  - **MV:** Recourse to mechanical ventilation.
  - **CT scan:** Two groups (<50% and >50% radiological lesions).
  - **Long stay in intensive care:** Measured in days. It was calculated as the date of discharge from the intensive care unit (by death, discharge, or transfer) minus the date of admission. Any patient who stayed for > 5 days was considered to have a long stay.
- **Data Analysis** Statistical analysis was performed using IBM SPSS statistical software (version 10). Continuous variables were expressed as mean +/- standard deviation and compared using the Student's t-test; categorical variables were expressed as percentages and compared using the Chi-square test or Fisher's exact test. Bivariate and multiple logistic regression models were used to generate unadjusted odds ratios (ORc) and adjusted odds ratios (ORa) with 95% confidence intervals (CI) for significance testing. Variables that reached a p-value < 0.05 in bivariate analysis were entered into the multiple logistic regression models.

The work was approved by the ethics committee of the Biomedical Research Faculty of the Faculty of Medicine and Pharmacy of Rabat.

3. Results

During the study period, among all patients who tested positive for SARS-CoV-2, 300 were admitted to intensive care. The mean age of the patients was 67 ± 11 years, and 217 were male (72.3%), with a male-to-female ratio of 2.61. The majority of patients had a medical comorbidity (Table 1), predominantly diabetes (35.7%), hypertension (31.8%), obesity (29.7%), cardiovascular diseases (20.3%), asthma (4.7%), COPD (7%), hypothyroidism (3.7%), chronic renal failure (3.3%), and neoplastic pathologies (4.3%). The number of patients who received mechanical ventilation was 69 (23%). One hundred seventy-eight (59.3%) had radiological lesions of less than 50%, and 122 (40.7%) had lesions >50%. The length of stay varied between 2 and 30 days, with a mean duration of 7.12 days and a median of 6 days (Graph I).

Table 1 Distribution of comorbidities in patients

		N	Pourcentage marginal
Sexe	F	82	27.3%
	M	218	72.7%
Age	<59	57	19.0%
	>59	243	81.0%
Obésité	Non	211	70.3%
	Oui	89	29.7%
Diabète	Non	193	64.3%
	Oui	107	35.7%
Hypothyroïdie	Oui	11	3.7%
	Non	289	96.3%
IRC	Oui	10	3.3%
	Non	290	96.7%
Pathologie néoplasique	Oui	13	4.3%
	Non	287	95.7%
Asthme	Oui	14	4.7%
	Non	286	95.3%
BPCO	Oui	21	7.0%
	Non	279	93.0%
Pathologie cardiaque	Oui	60	20.0%
	Non	240	80.0%
HTA	Non	205	68.3%
	Oui	95	31.7%
Décès	Oui	180	60.0%
	Non	120	40.0%

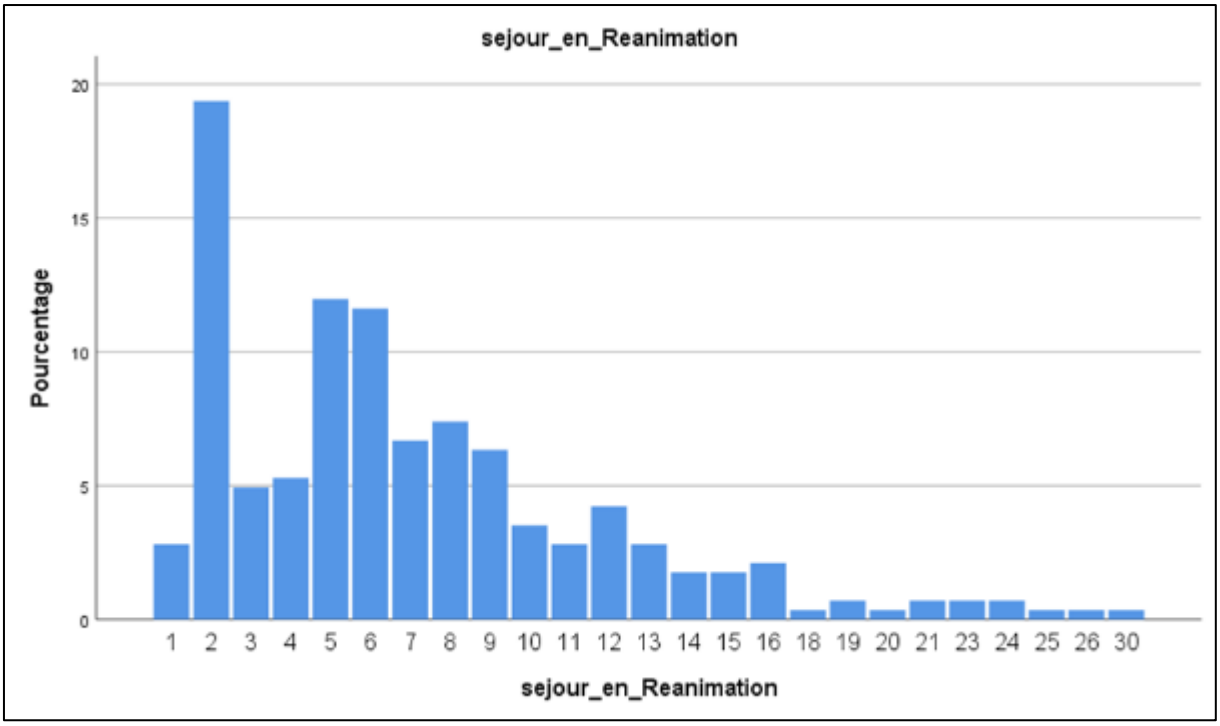

Figure 1 Disproportionate length of stay

Bivariate and multiple logistic regression models were used to generate unadjusted odds ratios (ORc) and adjusted odds ratios (ORa) with 95% confidence intervals (CI) for significance testing. Variables that achieved a p-value of <0.05 in the bivariate analysis were then entered into the multiple logistic regression models (Table 2 and 3).

Table 2 Characteristics of hospitalized patients with severe COVID-19 in relation to length of stay

variable	Categories	Total N (%)	Long séjour N (%) (LoS)	Court séjour N (%)	p-value
Age	<59	57 (19%)	38(19.8%)	19(17.6%)	0.64
	>59	243(81.3%)	154(80.2%)	89(82.4%)	
Sexe	Female	82(27.3%)	52(63.4%)	30(36.6%)	0.89
	Male	218(72.7%)	140(64.2%)	78(35.8%)	
Diabete	No	193(64.3%)	113(58.5%)	80(41.5%)	0.008
	Yes	107(35.7%)	79(73.8%)	28(26.2%)	
HTA	No	205(68.3%)	121(59%)	84(41%)	0.008
	Yes	95(31.7%)	71(74.7%)	24(25.3%)	
Obesité	No	211(70.3%)	117(55.5%)	94(44.5%)	<0.001
	Yes	89(29.7%)	75(84.3%)	14(15.7%)	
Pathologies cardiovasculaires	No	240(80%)	146(60.8%)	94(39.2%)	0.02
	Yes	60(20%)	46(76.7%)	14(23.3%)	
Asthme	Yes	14(4.7%)	7(50%)	7(50%)	0.26
	No	286(95.3%)	185(64.7%)	101(35.3%)	
BPCO	Yes	21(7%)	12(57.1%)	9(42.9)	0.49

	No	279	180(64.5%)	99(35.5)	
Hypothyroidism	Yes	17(5.7%)	11(64.4%)	6(35.3%)	0.95
	No	289	181(64%)	102(36%)	
Pathologies neoplasique	Yes	14(4.7%)	5(35.7%)	9(64.3)	0.024
	No	287	187(65.4%)	99(34.6%)	
IRC	Yes	17(5.7%)	11(64.7%)	6(35.3%)	0.95
	No	290	181(64%)	102(36%)	
VM	Yes	69(23%)	55(79.7%)	14(20.3%)	0.02
	No	231(77%)	137(59.3%)	94(40.7%)	
TDM	<50%	178(59.3%)	121(68%)	57(32%)	0.083
	>50%	122(40.7%)	71(58.2%)	51(41.8%)	

Table 3 Multivariate logistic regression analysis for the risk of prolonged ICU stay in severe COVID-19 patients

variable	**Categories**	**Total N(%)**	**Long séjour N(%)**	**Court séjour N(%)**	**ORc (IC95%)**	**ORa (IC95%)**
age	<59	57 (19%)	38(19.8%)	19(17.6%)	1.15(0.62-2,12)	
	>59	243(81.3%)	154(80.2%)	89(82.4%)		
sex	Female	82(27.3%)	52(63.4%)	30(36.6%)	0.96(0,57-1.63)	
	Male	218(72.7%)	140(64.2%)	78(35.8%)		
Diabetes	No	193(64.3%)	113(58.5%)	80(41.5%)	2(3.44-1.19)	2,55 (1,34-4,85) *
	Yes	107(35.7%)	79(73.8%)	28(26.2%)		
HBP	No	205(68.3%)	121(59%)	84(41%)	2.08(3.57-1.20)	0.86(0.44-1.67)
	Yes	95(31.7%)	71(74.7%)	24(25.3%)		
obesity	No	211(70.3%)	117(55.5%)	94(44.5%)	4.34 (8.33-2,32)	6.25(15.3-2.56)
	Yes	89(29.7%)	75(84.3%)	14(15.7%)		
Hearth diseases	No	240(80%)	146(60.8%)	94(39.2%)	2.12 (4.16-1.11)	1.34(0.54-3.14)
	Yes	60(20%)	46(76.7%)	14(23.3%)		
Asthma	Yes	14(4.7%)	7(50%)	7(50%)	0.54(0,18-1.60)	
	No	286(95.3%)	185(64.7%)	101(35.3%)		
BPCO	Yes	21(7%)	12(57.1%)	9(42.9)	0,73(0,29-1,80)	
	No	279	180(64.5%)	99(35.5)		
Hypothyroidism	Yes	17(5.7%)	11(64.4%)	6(35.3%)	1,033(0,37-2.87)	
	No	289	181(64%)	102(36%)		
Pathologie neoplasique	Yes	14(4.7%)	5(35.7%)	9(64.3)	3.44(10.41-1.11)	4(13.69-1.14)*

	No	287	187(65.4%)	99(34.6%)		
IRC	Yes	17(5.7%)	11(64.7%)	6(35.3%)	0.47(0,24-0,90)	
	No	290	181(64%)	102(36%)		
VM	Yes	69(23%)	55(79.7%)	14(20.3%)	2.69(1.41-5.12)	3.38(1.67-6.83)*
	No	231(77%)	137(59.3%)	94(40.7%)		
TDM	<50%	178(59.3%)	121(68%)	57(32%)	1.63(2.63-1.005)	
	>50%	122(40.7%)	71(58.2%)	51(41.8%)		

4. Discussion

It is crucial for ICU management to anticipate patient length of stay (LoS) to optimize bed occupancy, staffing, and equipment allocation, particularly during surges of severe viral pneumonia. Previous studies have reported LoS ranging from less than one week to nearly two months, while ICU stays are generally shorter and less variable, with medians of 1 to 3 weeks. When total LoS was stratified by discharge status, survivors tended to have longer overall hospital stays than non-survivors, but ICU stay alone showed less variation, and statistical comparisons were often not reported [13]. From a practical standpoint, differentiating between survivors and non-survivors before discharge has limited utility for real-time resource planning.

In our cohort, ICU stay ranged from 2 to 30 days, with a mean duration of 7.12 days, which is comparable to other studies reporting ICU LoS from 5 (IQR 2–9) to 19 days (IQR not reported). Unlike total hospital LoS, differences in ICU stay based on patient outcome (alive vs. deceased) were less pronounced. Eight studies have provided ICU LoS estimates, evenly split between Chinese and non-Chinese populations, with overall similar durations, underscoring the potential for generalizable patterns that can inform ICU capacity planning.

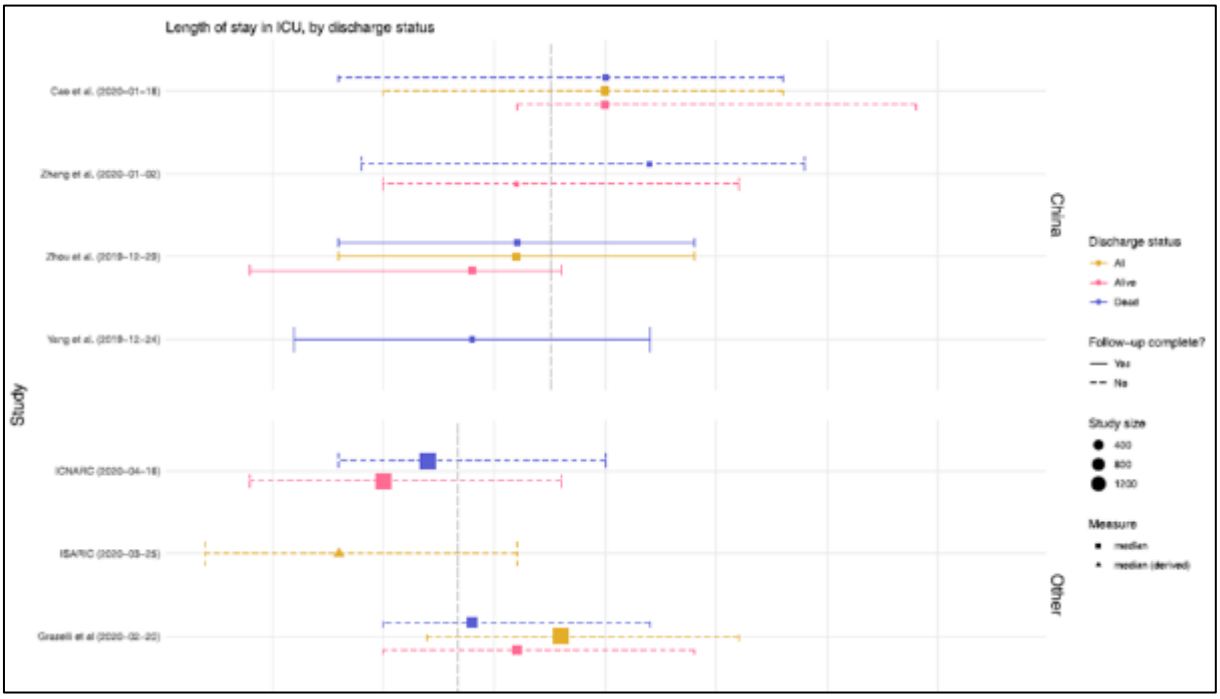

Figure 2 Length of stay in intensive care, by discharge status. Medians (squares) are presented with the interquartile range (IQR). When estimates were reported as mean and standard deviation, the equivalent quantiles were calculated assuming a Weibull distribution (triangle); if no measure of variation was reported, only the original mean is presented (circle). The gray dotted lines represent the average value of all point estimates within this framework, weighted by sample size. Studies are ranked by study start date

Few studies have formally investigated the determinants of prolonged ICU length of stay (LoS), particularly in a hospital setting for severe viral pneumonia. Cross-country comparisons are limited by differences in populations, healthcare systems, and local ICU capacities. Notably, definitions of what constitutes an ICU vary geographically, and ICU characteristics have been shown to differ substantially across regions [16].

4.1. Age

In our study, ICU LoS did not show a monotonic relationship with age (adjusted OR 1.15, 95% CI 0.62–2.12; p non-significant), indicating no significant association between age and prolonged stay. This finding contrasts with the well-documented relationship between age and disease severity or mortality [14]. It aligns, however, with previous observations in England [15]. Our cohort was highly selective, including only patients requiring ICU care, which may explain the lack of association; for similar disease severity, younger patients may be more likely to be admitted than older, frailer individuals [15].

4.2. Sex

No significant relationship was observed between patient sex and prolonged ICU stay (adjusted OR 0.96, 95% CI 0.57–1.63; p=0.89), consistent with findings from studies conducted in both China and England [15,20].

4.3. Obesity

Obesity emerged as a major determinant of prolonged ICU stay. Patients with a BMI >30 had an adjusted odds ratio (ORa) of 4.34 (95% CI 2.32–8.33; p <0.001), indicating that they were over four times more likely to experience a prolonged ICU stay compared with non-obese patients.

4.4. Comorbidities

Among the comorbidities analyzed, diabetes (ORa 2.55, 95% CI 1.34–4.85), hypertension (ORa 2.08, 95% CI 1.20–3.57), cardiovascular disease (ORa 2.12, 95% CI 1.11–4.16), and malignancy (ORa 3.44, 95% CI 1.11–10.41) were significantly associated with ICU stay in univariate analyses. In multivariate logistic regression, diabetes and malignancy remained independent predictors of prolonged ICU admission, highlighting their importance in resource planning.

4.5. Mechanical Ventilation

Requirement for mechanical ventilation was strongly associated with prolonged ICU stay (ORa 3.38, 95% CI 1.67–6.83), reflecting both disease severity and the increased complexity of patient management.

4.6. Radiological Findings

CT-assessed lung lesions did not significantly influence ICU length of stay (ORc 1.63, 95% CI 1.005–2.63), suggesting that imaging severity alone may not predict resource utilization.

4.7. International Comparisons

Studies comparing total hospital LoS between China and other countries reported shorter stays outside China (median 5 days, IQR 3–9 vs. 14 days, IQR 10–19). However, only five studies outside China provided LoS data, limiting the conclusiveness of these comparisons. Differences may reflect local ICU capacities, healthcare system pressures, and discharge criteria. For instance, some countries may have implemented less stringent discharge protocols or adapted treatment methods based on early Chinese data.

Regarding ICU LoS specifically, no significant differences were observed between China and other countries. Definitions of ICU and characteristics of units varied substantially across regions [17]. Most studies included patients with similar age distributions, generally skewed toward older cohorts, and age-stratified data were often incomplete. Some evidence suggests longer ICU stays in older patients [16–20], but results were inconsistent. Data on LoS by disease severity were also heterogeneous and could not be meaningfully synthesized.

4.7.1. England

In England, median ICU stay ranged from 5 (IQR 2–9) to 19 days (IQR not reported), with minimal variation based on discharge status (alive vs. deceased). Across eight studies reporting ICU LoS, four were from China and four from other countries, yielding broadly similar overall estimates. Data were insufficient to compare outcomes by age or disease severity.

In our studie, the mean ICU length of stay was over 16 days, with a median of nearly 11 days. These figures are comparable to ICNARC reports from England (12 days for survivors, 9 days for non-survivors; 10.8 days for either outcome on July 3; 10.1 days on June 5). Estimates were adjusted for censored cases, which typically have longer-than-average stays. International comparisons are limited by differences in population demographics and healthcare systems [17]. Notably, regions with higher proportions of elderly or vulnerable patients may require additional ICU resources to manage prolonged admissions effectively.

5. Conclusion

Our analysis identified mechanical ventilation, obesity, and malignancy as the primary independent predictors of prolonged ICU stay. Recognizing these determinants enables predictive modeling of ICU bed demand and informs strategic planning of critical care resources. Incorporating such factors into capacity management frameworks can optimize resource allocation, enhance preparedness for surges of severe viral pneumonia, and improve patient flow in intensive care settings.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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