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Treatment outcomes in Polish COVID-19 patients requiring hospitalisation in the intensive care unit: a single-centre retrospective study

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Abstract

Background: COVID-19 has disturbed the functioning of Polish healthcare for the past two years. Due to the high proportion of patients requiring admission to the intensive care unit (ICU), these wards are particularly overwhelmed and are considered the bottleneck of the healthcare system. The aim of this study was to describe clinical outcomes of critically ill patients treated in a single tertiary ICU in Poland, assess factors associated with mortality and compare outcomes of patients treated during the 2nd and 3rd waves of the pandemic.

Methods: This is a retrospective single-centre study including patients admitted to the ICU between October 2020 and May 2021 (the 3rd wave) with confirmed SARS-CoV-2 infection. Patients were followed up until death or 90 days after ICU admission. The co-primary endpoints of this study included ICU, 30-day and 90-day mortality.

Results: We enrolled 108 patients at a mean age of 64.3 (SD = 12) years, the majority of whom were male (63.9%). Mortality in the ICU, after 30 days and 90 days was 44.4% (48/108), 50.0% (54/108), and 57.9% (62/108), respectively. Mortality at 90 days was associated with increasing age (OR = 3.97, 95% CI: 1.87–8.41) and was significantly higher during the 2nd wave (65.6 vs. 46.5%, log-rank $P = 0.043$) compared to the 3rd wave of the pandemic.

Conclusions: This retrospective single-centre study confirms the high mortality rate among critically ill patients with COVID-19. Moreover, it suggests a significant association between 90-day mortality and increasing age as well as differences in mortality between the 2nd and 3rd waves of the pandemic in Poland.

Key words: intensive care unit, acute respiratory distress syndrome, COVID-19, SARS-CoV-2, mortality.

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The pandemic caused by SARS-CoV-2, ongoing for more than two years, has dominated public and scientific debates on an unprecedented scale. Thanks to the intense efforts of researchers, the risk factors for severe COVID-19 have been identified, including diabetes, obesity, cardiovascular diseases, and others [1]. Moreover, some treatment options, e.g., systemic glucocorticosteroids, tocilizumab, and baricitinib, have been confirmed to be effective in reducing mortality [2–4]. Nevertheless, mortality among critically ill people with COVID-19 remains high.

The dominant manifestation of SARS-CoV-2 infection is pneumonia, which often leads to acute respiratory failure requiring treatment in the hospital setting. According to estimates, about 5% of COVID-19 patients develop severe pneumonia and require admission to the intensive care unit (ICU) [5]. Given a high proportion of the population affected by COVID-19 infection, even such a low percentage leads to the overloading of ICUs in regions with many COVID-19 cases. As a result, ICUs admit critically ill patients, while the lack of available critical care beds often forces clinicians to make difficult decisions regarding eligibility for treatment in intensive care settings.

The COVID-19 pandemic in Poland did not differ significantly from the rest of the world. After a relatively mild first wave, the medical personnel had to

deal with the failure of the healthcare system during the second and third waves. Due to dramatic shortages of critical care beds and medical personnel observed for years, Polish physicians faced a challenging task. In initially overloaded ICUs, beds were almost immediately occupied by critically ill patients requiring invasive mechanical ventilation.

The primary objective of the present study was to evaluate the outcomes of critically ill patients treated in the participating centre. Moreover, we aimed to characterise and compare patients hospitalised in the ICU during the second and third waves of the COVID-19 pandemic in Poland and identify factors potentially associated with 90-day mortality in this population.

METHODS

Study design

A single-centre, retrospective observational study encompassed patients with positive SARS-CoV-2 RT-PCR test results and with respiratory failure admitted to the Department of Anaesthesiology and Intensive Care of Military Clinical Hospital no. 5 in Krakow. The study design was approved on 29th September 2021 by the Bioethics Committee of the Jagiellonian University, chaired by Prof. Dominika Dudek (decision number 1072.6120.191.2021). Informed consent of patients to participate in the study was not required.

Data collection and study population

The data were collected based on electronic medical records using the hospital information system. The study included all patients aged > 18 years with positive SARS-CoV-2 RT-PCR test results admitted to the ICU. The study was conducted between October 2020 and May 2021. Information on long-term treatment outcomes, complications, and recollections of the ICU stay was collected during telephone conversations conducted at least three months after discharge. At that time, patients were asked to evaluate: (1) whether they recovered fully after the ICU stay (possible answers were "yes" and "no") and (2) recovery of general fitness (from 0 to 100).

The detailed demographic data, information on comorbidities, the course of COVID-19 prior to ICU admission, and the treatment used during ICU hospitalization were gathered.

The data collected during the telephone history taking three months after hospitalization included the current place of stay (home, hospital, rehabilitation centre, care home), current ailments, use of rehabilitation services dedicated for patients after COVID-19, recollections of the ICU stay, or date of death, if applicable.

The co-primary endpoints included ICU, 30-day, and 90-day mortality. Secondary endpoints were the length of ICU stay, duration of mechanical ventilation, and complications observed during hospitalization (pneumothorax, venous thromboembolism, stroke, acute kidney injury, sudden cardiac arrest).

Moreover, the characteristics of patients treated in the ICU during the second and third waves (October 2020 – January 2021 and March 2021 – April 2021, respectively) of the COVID-19 pandemic were compared.

Statistical analysis

Categorical variables are presented as a number and percentage, while continuous variables are presented as a median with an interquartile range (IQR). If required, categorical variables were compared using the χ^2 test with Fisher's correction. Continuous variables were compared using the Mann-Whitney *U* test. Multivariable regression was carried out using logistic regression. The results were presented as the adjusted odds ratio (aOR) with 95% confidence intervals (CI). $P < 0.05$ was considered statistically significant.

RESULTS

Study population

The study included 108 COVID-19 patients hospitalised in the ICU, including 39 women (36.1%) and average age was 64.25 years (standard deviation 11.9). The 90-day follow-up was completed in 107/108 patients (99.1%). Detailed baseline demographic and clinical data are summarised in Table 1.

Treatment

The pharmacological treatment of COVID-19 in the ICU involved systemic corticosteroids (77/108; 72.0%) and remdesivir (3/108; 2.8%). Antibiotic therapy was used in 70 patients (64.8%). Invasive mechanical ventilation was delivered to 93.5% of patients during the ICU stay, and 52 patients (48.1%) were already ventilated on ICU admission. Further information about other therapeutic interventions is presented in Table 1.

Clinical incidents and treatment outcomes

The ICU, 30-day and 90-day mortality rates were 44.4% (48/108), 50.0% (54/108), and 57.9% (62/108), respectively. The most common complications included pulmonary embolism (29.6%), acute kidney injury (17.6%), and sudden cardiac arrest, which occurred in 18 (16.7%) patients. The incidence of all complications is described in Table 1.

TABLE 1. Characteristics of the study group and comparison of the second and the third wave of the pandemic

Characteristics	Total ($N = 108$)	Second wave ($n = 65$)	Third wave ($n = 43$)	*P*-value
Demographic data				
Age, years (mean)	64.3 (11.9)	65.5 (10.8)	62.4 (13.5)	0.192
Females, *n* (%)	39 (36.1)	25 (38.5)	14 (32.6)	0.674
Parameters on admission to ICU				
Duration of symptoms, days, median (IQR)	10.0 (6.0, 14.5)	11.0 (5.0, 15.0)	10.0 (7.0, 14.0)	0.897
APACHE II, median (IQR)	14.5 (10.0, 20.0)	17.0 (11.0, 21.0)	12.0 (8.5, 18.0)	0.010
Oxygenation ratio on admission, median (IQR)	95.0 (73.7, 138.2)	96.4 (72.2, 143.5)	94.0 (75.1, 123.0)	0.949
Shock on admission, *n* (%)	33 (30.8)	19 (29.7)	14 (32.6)	0.919
SCA prior to ICU admission, *n* (%)	9 (8.3)	7 (10.8)	2 (4.7)	0.441
Concomitant diseases				
Obesity, *n* (%)	52 (48.1)	32 (49.2)	20 (46.5)	0.936
Cardiovascular diseases, *n* (%)	77 (71.3)	46 (70.8)	31 (72.1)	1.000
Arterial hypertension, *n* (%)	64 (59.3)	37 (56.9)	27 (62.8)	0.684
Ischaemic heart disease, *n* (%)	22 (20.4)	15 (23.1)	7 (16.3)	0.539
Septal disease, *n* (%)	6 (5.6)	5 (7.7)	1 (2.3)	0.446
Atrial fibrillation, *n* (%)	16 (15.0)	13 (20.3)	3 (7.0)	0.105
Respiratory diseases, *n* (%)	14 (13.0)	10 (15.4)	4 (9.3)	0.530
COPD, *n* (%)	8 (7.4)	8 (12.3)	0 (0.0)	0.044
Asthma, *n* (%)	7 (6.5)	3 (4.6)	4 (9.3)	0.569
CKD, *n* (%)	3 (2.8)	3 (4.6)	0 (0.0)	0.406
Neoplastic disease, *n* (%)	1 (0.9)	1 (1.5)	0 (0.0)	1.000
Diabetes mellitus, *n* (%)	32 (29.6)	19 (29.2)	13 (30.2)	1.000
History of deep vein thrombosis, *n* (%)	19 (17.6)	11 (16.9)	8 (18.6)	1.000
Parameters associated with ICU stay; treatment				
Length of ICU stay, days, median (IQR)	11.0 (6.8, 19.0)	11.0 (6.0, 17.0)	13.0 (7.0, 22.0)	0.217
Sedation, *n* (%)	101 (93.5)	61 (93.8)	40 (93.0)	1.000
Duration of sedation, days, median (IQR)	8.5 (4.0, 14.0)	8.5 (4.0, 12.8)	9.0 (4.1, 14.0)	0.598
Antibiotic therapy – duration, median (IQR)	9.0 (6.0,14.0)	9.0 (7.0,13.8)	9.5 (6.0,15.3)	0.980
HFNOT, *n* (%)	48 (44.4)	29 (44.6)	19 (44.2)	1.000
Duration of HFNOT, days; median (IQR)	2.0 (1.0, 4.0)	2.0 (0.5, 4.0)	2.0 (1.0, 4,0)	0.368
NIV, *n* (%)	22 (20,4)	9 (13,8)	13 (30,2)	0,068
IMV prior to ICU admission, *n* (%)	52 (48,1)	31 (47,7)	21 (48,8)	1,000
Duration of IMV prior to ICU admission; days, median (IQR)	1,00 (1,0, 1.0)	1.00 (1.0, 1.0)	1.0(0.5, 2.0)	0.617
IMV in ICU, *n* (%)	101 (93.5)	60 (92.3)	41 (95.3)	0.819
Duration of IMV in ICU, days, median (IQR)	10.0 (6.0, 17.0)	9.3 (5.8, 16.3)	11.0 (6.0, 20.0)	0.484
Tracheostomy, *n* (%)	36 (33.6)	18 (28.1)	18 (41.9)	0.206
Prone position, *n* (%)	61 (57.0)	36 (55.4)	25 (59.5)	0.824
Duration of prone position, days, median (IQR)	3.0 (1.0, 4.0)	3.0 (1.8, 4.0)	2.0 (1.0, 3,0)	0.316
Vasopressors, *n* (%)	88 (81,5)	52 (80,0)	36 (83,7)	0.815
Duration of vasopressor use, days, median (IQR)	7,0 (3,0, 15.0)	6.0 (3.0, 12.5)	10.5 (5.0, 16.0)	0.079
Glucocorticosteroids, *n* (%)	77 (72.0)	37 (57.8)	40 (93.0)	< 0.001
Remdesivir, *n* (%)	3 (2.8)	0 (0.0)	3 (7.0)	0.118
ECMO, *n* (%)	2 (1.9)	0 (0.0)	2 (4.7)	0.305
CVVHD, *n* (%)	13 (12.0)	9 (13.8)	4 (9.3)	0.683
Duration of CVVHD, days, median (IQR)	4.0 (3.0, 5.0)	4.0 (4.0, 6.0)	3.8 (2.9, 4.6)	0.586

TABLE 1. Cont.

Characteristics	Total ($N = 108$)	Second wave ($n = 65$)	Third wave ($n = 43$)	*P*-value
Complications during ICU stay				
Pneumothorax, *n* (%)	7 (6.5)	2 (3.1)	5 (11.6)	0.171
Deep vein thrombosis, *n* (%)	7 (6.5)	4 (6.2)	3 (7.0)	1.000
Pulmonary embolism, *n* (%)	32 (29.6)	14 (21.5)	18 (41.9)	0.040
Acute kidney injury, *n* (%)	19 (17.6)	10 (15.4)	9 (20.9)	0.629
Cerebral stroke, *n* (%)	4 (3.7)	2 (3.1)	2 (4.7)	1.000
SCA, *n* (%)	18 (16.7)	12 (18.5)	6 (14.0)	0.725
Mortality				
ICU mortality, *n* (%)	48 (44.4)	30 (46.2)	18 (41.9)	0.809
30-day mortality, *n* (%)	54 (50.0)	35 (53.8)	19 (44.2)	0.432
90-day mortality, *n* (%)	62 (57.9)	42 (65.6)	20 (46.5)	0.043
Place of stay immediately after hospitalization				
Home, *n* (%)	38 (77.6)	18 (69.2)	20 (87.0)	
Care and treatment facility, *n* (%)	7 (14.3)	4 (15.4)	3 (13.0)	
Rehabilitation centre, *n* (%)	2 (4.1)	2 (7.7)	0 (0.0)	
Sanatorium, *n* (%)	2 (4.1)	2 (7.7)	0 (0.0)	

COPD – chronic obstructive pulmonary disease, CKD – chronic kidney disease, HFNOT – high-flow nasal oxygen therapy, NIV – noninvasive ventilation, IMV – intermittent mandatory ventilation, ECMO – extracorporeal membrane oxygenation, CVVHD – continuous veno-venous hemodialysis

Comparison of patients hospitalised during the second and third wave of the pandemic in Poland

Sixty-five patients were hospitalised during the second wave and 43 patients during the third wave of the pandemic. Computed tomography pulmonary angiography was performed less frequently during the second wave (43.1% vs. 67.4%, $P = 0.022$). Table 1 includes a detailed comparison of baseline variables, treatment modalities, and incidence of complications between the waves. The 90-day mortality was statistically significantly higher among patients hospitalised during the second wave of the pandemic compared to the third wave (65.6 vs. 46.5%, log-rank $P = 0.043$). Such an association was not observed in the comparison of 30-day mortality between the groups (53.8% vs. 44.2%, log-rank $P = 0.432$).

Factors associated with 90-day mortality

The univariate analysis of factors related to 90-day mortality is presented in Table 2.

Multivariable analysis showed a correlation between increased 90-day mortality and older age (OR = 3.97; 95% CI: 1.87–8.41); otherwise, a correlation with gender, APACHE scores, corticosteroid use, ICU oxygenation ratio, and pandemic wave (second vs. third) was not found. Detailed results of multivariate analysis are presented in Table 3.

Follow-up of discharged patients

After discharge from the hospital, most patients returned home (38/49; 77.6%), seven patients (14.3%) were referred to care and treatment facilities, and two patients (4.1%) were referred to rehabilitation centres and sanitaria. As reported by patients, 30.2% of them (13/43) fully recovered, and the median return of fitness assessed by patients was 75.0% (IQR 63.8 to 91.3). Moreover, 22.7% of patients (10/44) reported no recollections of the ICU stay, while fragmentary and complete recollections were reported by 40.9% (18/44) and 36.4% (16/44) of patients, respectively.

DISCUSSION

This single-centre retrospective observational study confirmed high mortality in COVID-19 patients treated in one of the Polish ICUs for respiratory failure. Interestingly, the 90-day mortality was found to be significantly higher in patients hospitalised during the second wave of the pandemic as compared to the third wave. A significant relationship between advancing age and increasingly high 90-day mortality indicates a highly unfavourable prognosis in elderly patients.

One of the main aims of the present study was to assess the treatment outcomes of COVID-19 patients in Polish ICUs and compare them with previous reports from Poland and the world. Scarce published reports on Polish critically ill COVID-19 patients have demonstrated even higher mortality rates than in our study. In a single-centre cross-sectional study involving 32 patients admitted to the ICU during the first three months of the pandemic, ICU mortality was 67%, compared to 44.4% in our study [6]. Such a significant disproportion

TABLE 2. Comparison according to 90-day survival after ICU admission

Characteristic	Survivors ($n = 45$)	Non-survivors ($n = 62$)	*P*-value
Demographic data			
Age, years (mean)	57.67 (12.1)	68.82 (9.5)	< 0.001
Females, *n* (%)	17 (37.8)	21 (33.9)	0.832
Parameters on ICU admission			
Duration of symptoms, days, median (IQR)	11.0 (7.0, 14.5)	10.0 (6.0, 14.5)	0.421
APACHE, median (IQR)	12.0 (9.0, 19.0)	17.0 (11.3, 21.8)	0.027
Oxygenation ratio on admission, median (IQR)	105.0 (89.0, 158.0)	87.9 (71.5, 120.0)	0.043
Shock on admission, *n* (%)	10 (22.7)	23 (37.1)	0.173
SCA prior to ICU admission, *n* (%)	3 (6.7)	6 (9.7)	0.841
Concomitant diseases			
Obesity, *n* (%)	30 (66.7)	21 (33.9)	0.002
Cardiovascular diseases, *n* (%)	28 (62.2)	48 (77.4)	0.135
Arterial hypertension, *n* (%)	25 (55.6)	38 (61.3)	0.692
Ischaemic heart disease, *n* (%)	8 (17.8)	14 (22.6)	0.715
Septal disease, *n* (%)	1 (2.2)	5 (8.1)	0.384
Atrial fibrillation, *n* (%)	1 (2.2)	15 (24.6)	0.004
Respiratory diseases, *n* (%)	4 (8.9)	9 (14.5)	0.562
COPD, *n* (%)	1 (2.2)	6 (9.7)	0.253
Asthma, *n* (%)	3 (6.7)	4 (6.5)	1.000
CKD, *n* (%)	0 (0.0)	3 (4.8)	0.366
Neoplastic disease, *n* (%)	0 (0.0)	1 (1.6)	1.000
Type 2 diabetes mellitus, *n* (%)	8 (17.8)	24 (38.7)	0.034
History of deep vein thrombosis, *n* (%)	9 (20.0)	10 (16.1)	0.794
Parameters regarding ICU stay; treatment			
Length of ICU stay, days, median (IQR)	9.0 (6.0, 24.0)	12.5 (7.0, 17.8)	0.559
Sedation, *n* (%)	42 (93.3)	58 (93.5)	1.000
Duration of sedation, days, median (IQR)	6.3 (4.0, 11.3)	11.0 (5.0, 14.5)	0.046
Antibiotic therapy in ICU, *n* (%)	26 (57.8)	43 (69.4)	0.303
Duration of ICU antibiotic therapy, days, median (IQR)	9.0 (6.0, 13.0)	9.5 (6.0, 14.0)	0.980
HFNOT, *n* (%)	24 (53.3)	24 (38.7)	0.192
Duration of HFNOT, days, median (IQR)	3.0 (1.0, 5.0)	1.0 (0.5, 3.0)	0.101
NIV, *n* (%)	14 (31.1)	7 (11.3)	0.021
IMV prior to ICU admission, *n* (%)	23 (51.1)	28 (45.2)	0.680
Duration of IMV prior to ICU admission, days, median (IQR)	1.0 (0.5, 2.0)	1.0 (1.0, 1.0)	0.950
IMV in ICU, *n* (%)	41 (91.1)	59 (95.2)	0.660
Duration of ICU IMV, days, median (IQR)	7.0 (5.0, 16.0)	12.0 (6.5, 17.0)	0.180
Tracheostomy, *n* (%)	11 (25.0)	25 (40.3)	0.152
Prone position, *n* (%)	24 (54.5)	36 (58.1)	0.872
Duration of prone position, days, median (IQR)	2.0 (1.0, 3.3)	3.0 (2.0, 4.0)	0.465
Vasopressors, *n* (%)	31 (68.9)	56 (90.3)	0.011
Duration of vasopressor use, days, median (IQR)	6.0 (3.0, 13.5)	7.50 (4.0, 15.3)	0.222
Glucocorticosteroids, *n* (%)	34 (75.6)	42 (68.9)	0.590
Remdesivir, *n* (%)	1 (2.2)	2 (3.2)	1.000
ECMO, *n* (%)	0 (0.0)	2 (3.2)	0.622
CVVHD, *n* (%)	4 (8.9)	9 (14.5)	0.562
Duration of CVVHD, days, median (IQR)	4.5 (3.6, 5.3)	4.0 (3.0, 5.0)	0.755

TABLE 2. Cont.

Characteristic	Survivors ($n = 45$)	Non-survivors ($n = 62$)	*P*-value
Complications during ICU stay			
Pneumothorax, *n* (%)	3 (6.7)	4 (6.5)	1.000
Deep vein thrombosis, *n* (%)	3 (6.7)	4 (6.5)	1.000
Pulmonary embolism, *n* (%)	17 (37.8)	15 (24.2)	0.193
Acute kidney injury, *n* (%)	5 (11.1)	14 (22.6)	0.202
Cerebral stroke, *n* (%)	2 (4.4)	2 (3.2)	1.000
SCA, *n* (%)	1 (2.2)	17 (27.4)	0.001

COPD – chronic obstructive pulmonary disease, CKD – chronic kidney disease, HFNOT – high-flow nasal oxygen therapy, NIV – noninvasive ventilation, IMV – intermittent mandatory ventilation, ECMO – extracorporeal membrane oxygenation, CVVHD – continuous veno-venous hemodialysis

may result from the initially more severe clinical conditions of patients in the cited study, which is reflected in higher average APACHE II scores (average 20.1 vs. 15.1). On the other hand, the significant impact of the growing experience of clinicians and the gradual broadening of knowledge about the pathophysiology and treatment of COVID-19 cannot be ignored; such advances have made it possible to find therapeutic options reducing mortality in this population. The other two studies did not directly involve patients treated in the ICU yet reported mortality in this group of patients. One of the above-mentioned studies was retrospective and involved patients hospitalised due to COVID-19 during the first month of the pandemic; the other study was prospective and focused on treatment outcomes of patients requiring high-flow nasal oxygen therapy (HFNOT) for COVID-19-related respiratory failure; most patients were recruited during the second wave of the pandemic. The mortality rates of patients requiring ICU hospitalization reported in the above studies were 58.6% (hospital mortality) and 64.7% (30-day mortality), respectively [7, 8]. High mortality observed in the second study may be associated with delayed intubation due to the use of HFNOT, as compared to passive oxygen therapy. Another Polish observational study revealed that mortality among patients with acute respiratory failure and baseline oxygenation index ≤ 300 mmHg was 32%; however, mortality in a subgroup of patients requiring invasive mechanical ventilation reached 66.7% and was markedly higher compared to our cohort [9]. Unfortunately, the lack of detailed data on patients transferred to the ICU makes it impossible to confirm a relationship between the clinical characteristics of patients and treatment outcomes.

The comparison of the results of the above observations with reports from other countries leads to quite different conclusions. It is worth emphasizing that even before the era of COVID-19, there were some alarming reports on extremely high mortality in Polish ICUs [10, 11]. Nevertheless, meticulous analyses have revealed that the excess mortality observed in critically ill patients in Poland resulted largely from more severe conditions of patients on admission to the ICU. The comparative analysis of our findings with the results of extensive studies performed in other countries has shown a significantly higher mortality rate in our population of critically ill COVID-19 patients. In a retrospective study of 3795 critically ill patients from 73 Spanish, Irish and Andorran centres, the ICU mortality rate was 30.7% [12]. In another large prospective study, which included 4244 patients from 138 hospitals in France, Belgium, and Switzerland, the 90-day mortality rate was 31.0% [13]. However, the observed significant differences in treatment outcomes seem to be largely associated with the diversities between the Polish population and Western European populations of ICU patients. On the one hand, in the above-mentioned studies, invasive mechanical ventilation was used in 80% and 76.1% of cases, respectively, while in our study, this percentage was 93.5%. This, together

TABLE 3. Results of multivariate analysis

Factors	OR	95% CI	*P*-value
Gender	0.67	0.25–1.83	0.4404
Age	3.97	1.87–8.41	0.0003
APACHE	1.46	0.66–3.22	0.3476
Corticosteroids	0.58	0.17–1.99	0.3897
P/F on admission	0.74	0.48–1.14	0.1759
Wave	0.73	0.26–2.06	0.5527

with the significantly lower baseline oxygenation index in our study ($PaO_2/FiO_2 = 95$) compared to studies by Carbonell *et al*. ($PaO_2/FiO_2 = 122$) and Schmidt *et al*. ($PaO_2/FiO_2 = 154$), may indicate higher severity of respiratory failure among Polish patients admitted to the ICU. Another important factor negatively affecting the prognosis of Polish patients is more pronounced multimorbidity in our cohort compared to previously mentioned reports. On the other hand, both age and APACHE II scores on admission to the ICU were similar. Undoubtedly, the discrepancies in the organization of the healthcare system in Poland and Western countries are of great importance. One of the most relevant indicators of the healthcare system quality is the proportion of ICU beds to the total number of hospital beds, which is 2.7% in Poland and 4.9% in Western countries [14]. As a result, in the era of the pandemic and huge overload of the healthcare system, only patients in the most severe conditions, predominantly requiring endotracheal intubation and mechanical ventilation, were admitted to the Polish ICUs, which translated into unfavourable statistics of treatment outcomes.

Another aspect evaluated in our study was the comparison of treatment outcomes in the two waves of the pandemic. The 90-day mortality during the second wave was almost 20% higher than that in the third wave. This finding is probably largely explained by higher baseline APACHE II scores of patients hospitalised during the second wave and less frequent use of glucocorticoids, which are one of the few treatment options significantly reducing mortality of COVID-19 patients [4]. The reason for such a large difference in APACHE II score between the waves is not clear but may be related to the higher proportion of pre-ICU sudden cardiac arrests, chronic obstructive pulmonary disease (COPD), and higher age among patients admitted during the second wave. Another potentially relevant difference was associated with higher incidences of pulmonary embolism diagnoses during the third wave. It is worth emphasizing, however, that the multivariable analysis did not confirm the relationship between 90-day mortality and the pandemic wave, which is most likely related to the fact that the key prognostic factor in this population of patients is age.

Considering the disproportion between the demand and the availability of ICU beds, it seems reasonable to look for factors identifying patients who might not benefit from treatment in the intensive care setting. The multivariable analysis showed a significant relationship between increased mortality and the increasing age of patients. Patients who died within 90 days of admission were older. This finding is consistent with numerous European studies showing a link between advanced age and increased mortality during COVID-19 [13, 15, 16]. However, advanced age cannot be considered the only factor when assessing suitability for ICU treatment. In this context, the results of the COVIP study are worth mentioning; they have demonstrated an association between increased mortality and advanced age, but also higher Clinical Frailty Scale (CFS) scores [17]. The great usefulness of this scale for predicting treatment outcomes in ICU elderly patients has also been confirmed by pre-pandemic studies, e.g., the VIP1 and VIP2 studies [18, 19]. Considering the above, one of the key aspects of adequate use of the available resources of the healthcare system should be mentioned, i.e., rational qualification of patients for treatment in the ICU. Due to numerous systemic conditions, including legislative, cultural, and religious ones, especially the lack of a uniform procedure for limiting potentially futile procedures, ICUs admit patients with an extremely poor prognosis and very low chances of benefiting from advanced treatment options. Once current scientific data and clinical experience of intensivists are taken into consideration, this aspect of care can be improved, enabling better distribution of the limited resources of the Polish healthcare system and preventing the exposure of patients to unnecessary suffering.

Our study has some limitations. First, the retrospective design of this study is associated with an increased risk of systematic bias. Second, the lack of protocolised ICU admission criteria may lead to selection bias. Third, it is difficult to extrapolate the study results to the general population as the patients involved were treated in one centre. Finally, the study sample was relatively small, and the inclusion of potentially relevant factors in multivariable analysis was limited.

CONCLUSIONS

The current retrospective study confirmed high mortality rates of patients treated in the intensive care unit for COVID-19 compared to other European countries. Moreover, mortality was shown to be particularly high in patients treated during the second wave of the pandemic and was associated with the increasing age of patients.

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REFERENCES

1. Williamson E, Walker AJ, Bhaskaran K, et al. OpenSAFELY: factors associated with COVID-19-related hospital death in the linked electronic health records of 17 million adult NHS patients. medRxiv. Epub ahead of print 2020. doi: 10.1101/2020.05.06.20092999.
2. Marconi VC, Ramanan AV, de Bono S, et al. Efficacy and safety of baricitinib for the treatment of hospitalised adults with COVID-19 (COV-BARRIER): a randomised, double-blind, parallel-group,

placebo-controlled phase 3 trial. Lancet Respir Med 2021; 9: 1407-1418. doi: 10.1016/S2213-2600(21)00331-3.
3. WHO Rapid Evidence Appraisal for COVID-19 Therapies (REACT) Working Group; Shankar-Hari M, Vale CL, Godolphin PJ, et al. Association between administration of IL-6 antagonists and mortality among patients hospitalized for COVID-19: a meta-analysis. JAMA 2021; 326: 499-518. doi: 10.1001/jama.2021.11330.
4. WHO Rapid Evidence Appraisal for COVID-19 Therapies (REACT) Working Group; Sterne JAC, Murthy S, Diaz JV, et al. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. JAMA 2020; 324: 1330-1341. doi: 10.1001/jama.2020.17023.
5. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020; 323: 1239-1242. doi: 10.1001/jama.2020.2648.
6. Kokoszka-Bargieł I, Cyprys P, Rutkowska K, et al. Intensive care unit admissions during the first 3 months of the COVID-19 pandemic in Poland: a single-center, cross-sectional study. Med Sci Monit 2020; 26: e926974. doi: 10.12659/MSM.926974.
7. Nowak B, Szymański P, Pańkowski I, et al. Clinical characteristics and short-term outcomes of patients with coronavirus disease 2019: a retrospective single-center experience of a designated hospital in Poland. Pol Arch Intern Med 2020; 130: 407-411. doi: 10.20452/pamw.15361.
8. Celejewska-Wójcik N, Polok K, Górka K, et al. High-flow nasal oxygen therapy in the treatment of acute respiratory failure in severe COVID-19 pneumonia: a prospective observational study. Pol Arch Intern Med 2021; 131: 658-665. doi: 10.20452/pamw.16015.
9. Piwowarczyk P, Szczukocka M, Kutnik P, et al. Risk factors and outcomes for acute respiratory failure in coronavirus disease 2019: an observational cohort study. Adv Clin Exp Med 2021; 30: 165-171. doi: 10.17219/acem/130603.
10. Vincent JL, Marshall JC, Ñamendys-Silva SA, et al. Assessment of the worldwide burden of critical illness: the Intensive Care Over Nations (ICON) audit. Lancet Respir Med 2014; 2: 380-386. doi: 10.1016/S2213-2600(14)70061-X.
11. Weigl W, Adamski J, Goryński P, et al. Mortality rate is higher in Polish intensive care units than in other European countries. Intensive Care Med 2017; 43: 1430-1432. doi: 10.1007/s00134-017-4804-2.
12. Carbonell R, Urgelés S, Rodríguez A, et al. Mortality comparison between the first and second/third waves among 3,795 critical COVID-19 patients with pneumonia admitted to the ICU: a multicentre retrospective cohort study. Lancet Reg Health Eur 2021; 11: 100243. doi: 10.1016/j.lanepe.2021.100243.
13. Schmidt M, Hajage D, Demoule A, et al. Clinical characteristics and day-90 outcomes of 4244 critically ill adults with COVID-19: a prospective cohort study. Intensive Care Med 2021; 47: 60-73. doi: 10.1007/s00134-020-06294-x.
14. Bauer J, Brüggmann D, Klingelhöfer D, et al. Access to intensive care in 14 European countries: a spatial analysis of intensive care need and capacity in the light of COVID-19. Intensive Care Med 2020; 46: 2026-2034. doi: 10.1007/s00134-020-06229-6.
15. Karagiannidis C, Mostert C, Hentschker C, et al. Case characteristics, resource use, and outcomes of 10 021 patients with COVID-19 admitted to 920 German hospitals: an observational study. Lancet Respir Med 2020; 8: 853-862. doi: 10.1016/S2213-2600(20)30316-7.
16. Grasselli G, Greco M, Zanella A, et al. Risk factors associated with mortality among patients with COVID-19 in intensive care units in Lombardy, Italy. JAMA Intern Med 2020; 180: 1345-1355. doi: 10.1001/jamainternmed.2020.3539.
17. Jung C, Flaatten H, Fjølner J, et al. The impact of frailty on survival in elderly intensive care patients with COVID-19: the COVIP study. Crit Care 2021; 25: 149. doi: 10.1186/s13054-021-03551-3.
18. Fronczek J, Polok K, Nowak-Kózka I, et al. Frailty increases mortality among patients = 80 years old treated in Polish ICUs. Anaesthesiol Intensive Ther 2018; 50: 245-251. doi: 10.5603/AIT.a2018.0032.
19. Fronczek J, Polok K, de Lange DW, et al. Relationship between the Clinical Frailty Scale and short-term mortality in patients ≥ 80 years old acutely admitted to the ICU: a prospective cohort study. Crit Care 2021; 25: 231. doi: 10.1186/s13054-021-03632-3.