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Research Article

Decoding Adversity: Predictors of Poor Outcomes in Admitted COVID-19 Patients-A Retrospective Single Institute Study

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Abstract

Background and Objective: The emergence of COVID-19 necessitated the establishment of dedicated treatment units globally. This study examines patient outcomes and risk factors in a cohort of COVID-19 patients at the Provincial Specialist Hospital in Olsztyn. **Materials and Methods:** Patients admitted to the COVID-19 Department of the Provincial Specialist Hospital in Olsztyn between November 28, 2021 and February 28, 2022, were retrospectively analysed. Data including age, gender, ASA classification, vaccination status and percentage of lung involvement by COVID-19 lesions were extracted from electronic medical records. **Results:** The overall mortality rate is 27%. Patients classified as ASA III had the highest mortality rate (36.5%), followed by those classified as ASA IV (55.6%). Multivariate analysis showed that patients over 80 years old had a 4.35 times higher risk of death than those under 60 years of age (aHR 4.35, 95% CI 1.13-16.61, $p < 0.05$). Furthermore, for every 1% increase in lung involvement due to COVID-19 lesions, the mortality risk increased by 2% (aHR 1.02, 95% CI 1.01-1.03, $p = 0.0001$). Among hospitalized patients, 14% were fully vaccinated. This study found that unvaccinated individuals had a four-fold higher risk of death than fully vaccinated patients (OR 3.9, 95% CI 1.1-13.9, $p < 0.05$). Additionally, Kaplan-Meier survival analysis showed that fully vaccinated patients had a 100% survival probability at 9 days, whereas unvaccinated individuals had a survival probability of only 78.6% ($p < 0.05$). **Conclusion:** Age and percentage of lung involvement were significant predictors of mortality in COVID-19 patients, while ASA classification showed limited predictive value. Routine chest CT scans and vaccination status emerged as crucial determinants of patient outcomes, emphasizing the importance of comprehensive clinical assessments and vaccination strategies in managing COVID-19.

Key words: Radiographic findings, prognostic markers, comorbidities, COVID-19, mortality rate

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Coronavirus Disease 2019 (COVID-19) emerged in 2019 as a viral respiratory illness, originating in China and rapidly evolved into a global pandemic. The escalating global impact necessitated the establishment of dedicated treatment units, exemplified by the inauguration of the COVID-19 Department at the Provincial Specialist Hospital in Olsztyn on November 28, 2021. This department, equipped with 25 beds, aimed to address the increasing burden of infections.

The diagnostic regimen in the COVID-19 Department encompassed tests for C-Reactive Protein (CRP), IL-6, D-dimer, creatinine, electrolytes, procalcitonin, along with COVID-19 identification through throat swabs and chest Computed Tomography (CT) scans.

This study delves into the outcomes of 200 COVID-19 patients treated at the Provincial Specialist Hospital in Olsztyn between November 28, 2021 and February 28, 2022. By scrutinizing patient characteristics, this research contributes insights into the disease's manifestation within our specific healthcare context.

The significance of this research lies in its potential to inform clinical practices and improve patient outcomes. As the pandemic unfolded, the need for tailored therapeutic approaches became increasingly evident. Exploring risk factors in COVID-19 patients and evaluating the utility of the ASA Physical Status Classification System in predicting clinical severity aims to enhance understanding and treatment strategies.

Positioned within the broader scientific discourse on COVID-19, this paper addresses gaps in current knowledge and establishes a foundation for further research in this critical domain.

In summary, the objective was to present a detailed analysis of COVID-19 patient characteristics at the Provincial Specialist Hospital in Olsztyn, shedding light on potential risk factors and evaluating the efficacy of a widely used classification system in predicting clinical outcomes.

MATERIALS AND METHODS

Study area: The hospitalized patients in the COVID-19 Department of the Provincial Specialist Hospital in Olsztyn, located in Northeastern Poland, were analysed in this retrospective study. The study focused on individuals diagnosed with moderate-to-severe COVID-19 according to the provisional guidelines established by the World Health Organization. The study was conducted between November 28, 2021 and February 28, 2022, with 200 patients admitted to

the Provincial Specialist Hospital in Olsztyn. The collected data was analysed.

Study design: Demographic, clinical, laboratory, treatment and outcome data were extracted from electronic medical records.

Routine chest computed tomography was performed for almost every patient admitted to the COVID-19 ward. The exception was very ill patients who died before the study. The percentage of lung involvement changes described as "ground-glass" was evaluated by a radiologist working in the Radiology Department of the Olsztyn Hospital. The decision to include the subjective results of chest CT radiological evaluations in the study was made based on the excellent interobserver agreement demonstrated in the previous validation study¹. Several descriptions of CT examinations had no numerical values. If the lungs were asymmetrically affected (e.g., 70% left lung, 40% right lung), the result taken into account was the arithmetic mean of the two percentages.

Statistical analysis: Continuous variables are represented as either mean with standard deviation (SD) or median with Interquartile Range (IQR). In instances of non-normally distributed data, the Kruskal-Wallis test was employed. For the analysis of non-normally distributed continuous variables, the Mann-Whitney U test was applied. Categorical variables are reported as frequency rates and percentages and were assessed using the χ^2 test or Fisher's exact test properly. Univariate and multivariate Cox proportional hazard models were used for survival analysis. Proportional hazard assumptions were checked using Schoenfeld residuals and Wald test. Statistical significance was set at 0.05. Statistical analysis were performed using STATISTICA software (version 13.0) and Microsoft Excel.

Ethical consideration: The study was approved (number SZJ.F 136/1; 17.01.2022) by the research ethics commission of Provincial Specialist Hospital in Olsztyn.

RESULTS AND DISCUSSION

Demographic characteristics: The median age was 69 years (IQR 59-78 years) and 49% of the patients were female. Three patients were not assigned to any ASA group because their medical histories were incomplete. Patients with ASA III were older than those with ASA I and ASA II and at the same time, patients with ASA I were younger than those with ASA I-IV. There were more men with ASA I than women with ASA I. As 54 in-hospital deaths occurred in this study. The deaths

occurred in patients in all ASA groups, most of which (35 patients [65%]) were in patients with ASA III and five (9%) in patients with ASA IV. There were differences between the two groups: More patients died with ASA III than with ASA I or IV ($p = 0.0002$ and $p = 0.005$, respectively). The length of stay, transfers to the Intensive Care Unit (ICU) and smokers were not significantly different across the ASA comparisons (Table 1).

The median length of hospital stay was 9 days (IQR, 6-12 days) for all inpatients. The length of stay was longer when admissions included patients who survived (median 10 days [IQR 7-12]) than when admissions included patients who died (6 days [IQR 2-11], $p = 0.0002$) (Fig. 1).

Risk factors for inpatient mortality: Age, gender, ASA, structure of vaccination and the percentage of lung involvement by COVID-19 are the risk factors for hospital mortality. The characteristics of these factors were presented in Table 2.

Increasing age was associated with decreased survival probability; compared with patients younger than 60 years, patients older than 80 years had a six times higher rate of death (95% CI 2.13 to 17.80). Patients with ASA IV had a higher mortality rate than those with ASA I (HR 3.12, 95% CI 0.74 to 13.12). A 1% increase in the level of lung involvement by COVID-19 lesions decreased survival probability by 2%. No difference in survival probability was observed between men and women and those who were unvaccinated and vaccinated by only the first dose or only two doses compared to fully vaccinated patients.

Covariates in the multivariable Cox proportional hazards model were age, ASA PS classification and percentage of lung involvement by COVID-19 (Table 3). In this model, 4.4 times higher rate of death was observed in patients older than 80 years compared with patients younger than 60 years (95% CI 1.13 to 16.61), an 80% lower rate of death in ASA II patients compared with ASA I patients and the same results for degree of lung involvement by COVID-19 lesions.

Table 1: Demographic characteristics of the patients

Variables	Total (n = 200)	ASA I (n = 14)	ASA II (n = 78)	ASA III (n = 96)	ASA IV (n = 9)	p-value					
						I vs II	I vs III	I vs IV	II vs III	III vs IV	IV vs II
Age (years)	69 (59-78)	56 (37-59)	66 (51-74)	71.5 (63.5-83)	70 (67-83)	0.009	<0.0001	0.002	0.0001	0.8	0.1
Female	98 (49%)	3 (21.4%)	41 (52.6%)	47 (49%)	4 (44.4%)	0.04 [†]	0.08 [†]	0.4 [†]	0.6*	1.0 [†]	0.7 [†]
Male	102 (51%)	11 (78.6%)	37 (78%)	49 (51%)	5 (55.6%)	-	-	-	-	-	-
Death	54 (27%)	3 (21.4%)	9 (11.5%)	35 (36.5%)	5 (55.6%)	0.4 [†]	0.4 [†]	0.2 [†]	0.0002*	0.3 [†]	0.005 [†]
Length of stay (days)	9 (6-12)	7 (6-9)	10 (7-12)	9 (6-12)	6 (1-10)	0.055	0.2	0.4	0.7	0.09	0.054
Transfer to the ICU	9 (4.5%)	2 (14.3%)	4 (5%)	3 (3%)	0 (0%)	0.2 [†]	0.1 [†]	0.5 [†]	0.7 [†]	1.0 [†]	1.0 [†]

Data are presented as the median (IQR) or n (%), categorical variables were analysed using the χ^2 test and [†]Fisher's exact test

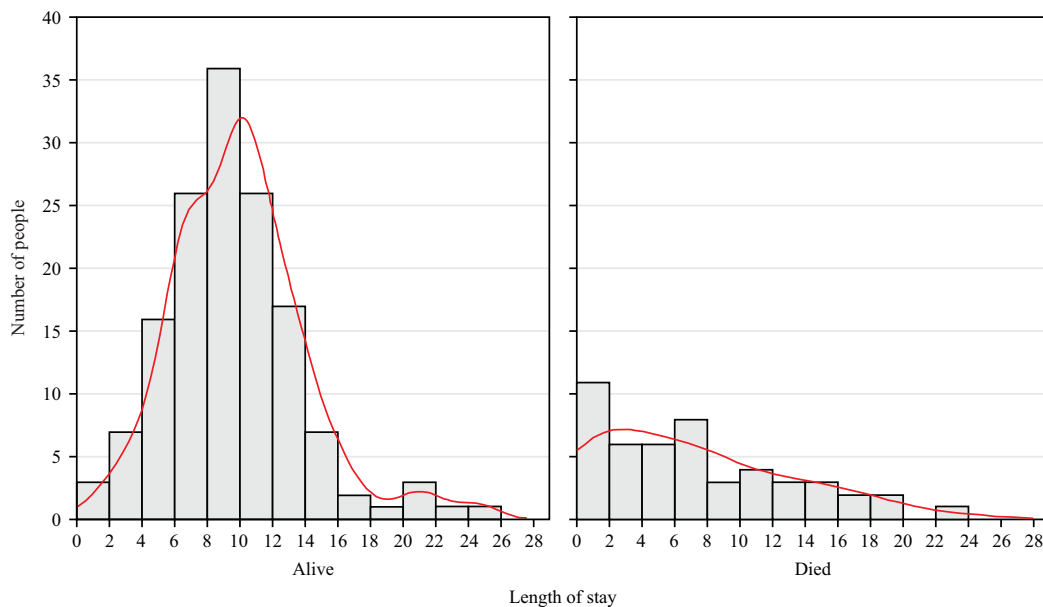


Fig. 1: Plot of patient length of stay by patients who are alive and who died

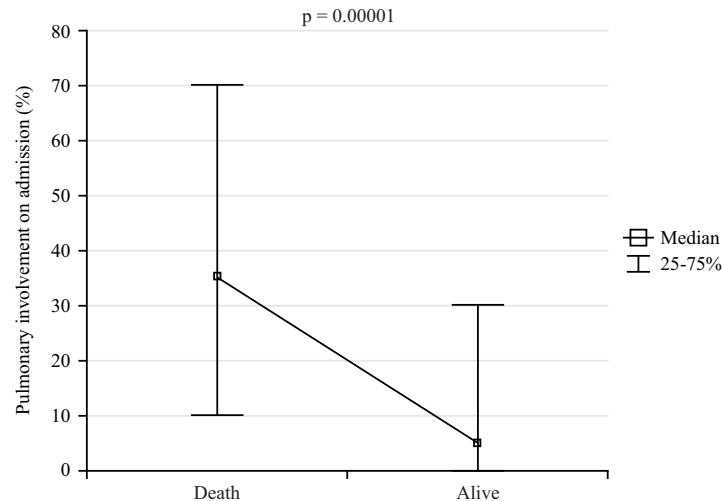


Fig. 2: Box-and-whisker plot for the percentage of lung involvement by COVID-19 lesions on CT in patients who died during hospitalization and who survived

Table 2: Characteristics of patients admitted with PCR confirmed or clinically diagnosed COVID-19 by HRs from univariate Cox regression

Variables	Total	Deaths	HR	95% CI	p-value
Age					
<60	51	4	Ref.	-	-
60-80	104	26	2.53	0.88-7.30	0.95
>80	45	24	6.15	2.13-17.80	0.00007
Gender					
Men	102	27	Ref.	-	-
Women	98	27	0.96	0.56-1.65	0.89
ASA					
I	14	3	Ref.	-	-
II	78	9	0.15	0.04-0.59	0.002
III	96	35	1.22	0.37-4.00	0.75
IV	9	5	3.12	0.74-13.12	0.007
Structure of vaccination					
Fully vaccinated	27	3	Ref.	-	-
First dose only or two doses only	78	20	1.78	0.52-6.03	0.59
Unvaccinated	95	31	2.11	0.64-6.99	0.20
Percentage of lung involvement by COVID-19	-	-	1.02	1.01-1.03	0.00002

Description of chest computed tomography of patients on admission: In 177 cases of patients with a percentage of lung involvement in chest CT, on average, from the mean of 21%, the percentage of pulmonary lesions deviated by 24%.

It examined how the percentage of lung involvement differed in the group of patients who died during hospitalization and those who survived. It has been proven (with a significance level $p = 0.00001$) that these groups are different in terms of the variable determining lung involvement. In the group of surviving patients, the median lung involvement was 5% (IQR 0-30%), while in the group of patients who died -35% (IQR 10-70%) (Fig. 2).

In addition, it was proved that the percentage of lung involvement with changes characteristic of COVID-19 was

different in the groups of patients with different vaccination profiles. The *post hoc* test and the box-and-whisker plot (Fig. 3) showed that unvaccinated individuals had a greater percentage of pulmonary parenchyma affected than those who had received at least one dose of the COVID-19 vaccine. Fully vaccinated people had the least radiographically altered lungs.

No differences in the degree of lung involvement between patients with different grades of ASA (Kruskal-Wallis test, $p = 0.54$) was present.

Vaccination profile: Structure of vaccination profile among the patients of the Provincial Specialist Hospital in Olsztyn as presented on Fig. 4 and 5 showed structure of the type of vaccine received by patients.

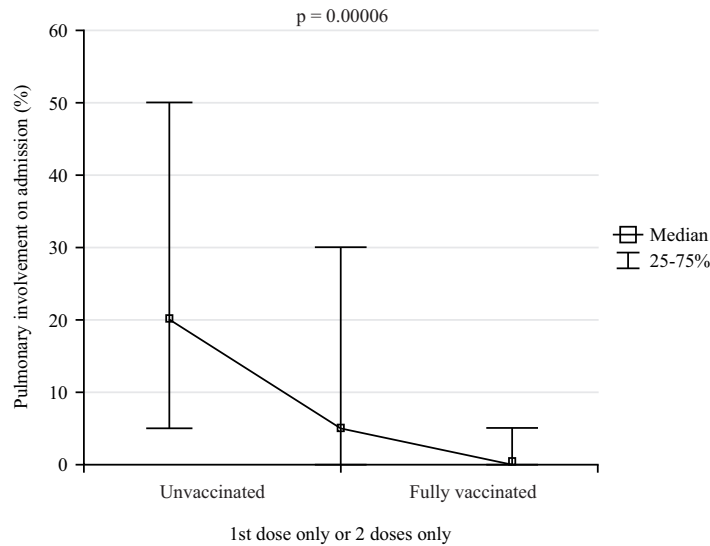


Fig. 3: Box-and-whisker plot for the percentage of lung involvement by COVID-19 lesions on CT in patients with different vaccination profiles

Table 3: Characteristics of patients admitted with PCR confirmed or clinically diagnosed COVID-19 by adjusted HRs from multivariable Cox regression

Variables	aHR	95% CI	p-value
Age			
<60	Ref.	-	-
60-80	2.26	0.64-7.89	0.84
>80	4.35	1.13-16.61	0.02
ASA			
I	Ref.	-	-
II	0.20	0.04-1.07	0.04
III	0.64	0.15-2.84	0.70
IV	1.26	0.17-9.30	0.35
Percentage of lung involvement by COVID-19	1.02	1.01-1.03	0.0001

About half of the patients hospitalized in COVID-19 department in Olsztyn were not vaccinated. Complete vaccination (i.e., receiving two doses of Comirnaty, Moderna, AstraZeneca or one dose of Janssen vaccine and additionally receiving a third (booster) dose of Comirnaty or Moderna) was achieved by only 14% of those admitted to the ward. The median age of fully vaccinated patients is 75 years (IQR 69-83), with the majority being ASA Grade III or IV (67%).

The most popular preparation amongst patients hospitalized in the COVID-19 department was the vaccine from Pfizer and Comirnaty.

Data on influenza vaccinations among patients was available. However, only 3% of individuals had received vaccinations. The possibility for patients to privately purchase the vaccine in Poland may be significantly underestimating the number of vaccinated patients, as their data is not included in the national register.

Since statistical significance was not achieved in the Cox regression model when examining the effect of the inoculation profile on the relative risk of death, the univariate

logistic regression model was chosen, with patient death as a model variable. The odds ratio (OR) of 3.9 (1.1-13.9), $p = 0.037$, indicated that the unvaccinated population had an odds four times higher than the fully vaccinated population.

The Kaplan-Meier cumulative function was used to illustrate the 9-day survival probability for the three-dose vaccinated and unvaccinated groups-the results are 100% and 78.6%, respectively, $p = 0.042$ (Fig. 6).

The authors of the above work deliberately conducted studies on the impact of the vaccination profile of patients on mortality using previously unplanned statistical models, because in the era of highly developed anti-vaccination movements, the study could become a victim of interpretive manipulation, e.g., in the form of the statement that since aHR values did not reach significance $p < 0.05$, then the vaccines are ineffective and that would be an incorrect conclusion.

The American Society of Anesthesiologists (ASA) physical status is routinely used to classify a patient's fitness before surgery. The aim of this system is to estimate and report a patient's pre-anesthesia medical comorbidities². This is a

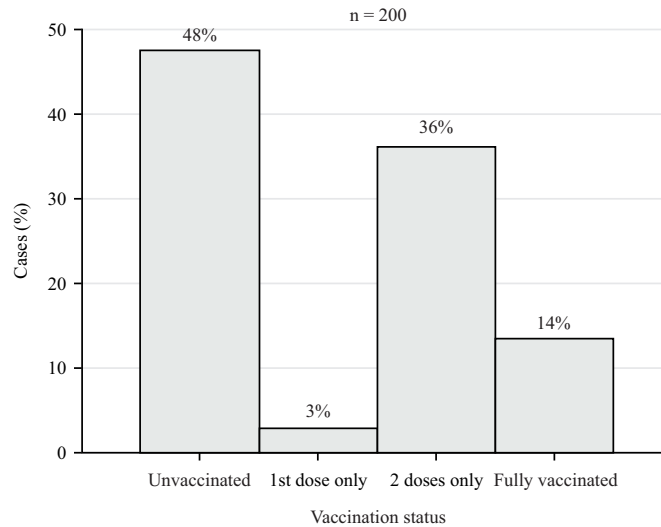


Fig. 4: Structure of vaccination profile among patients

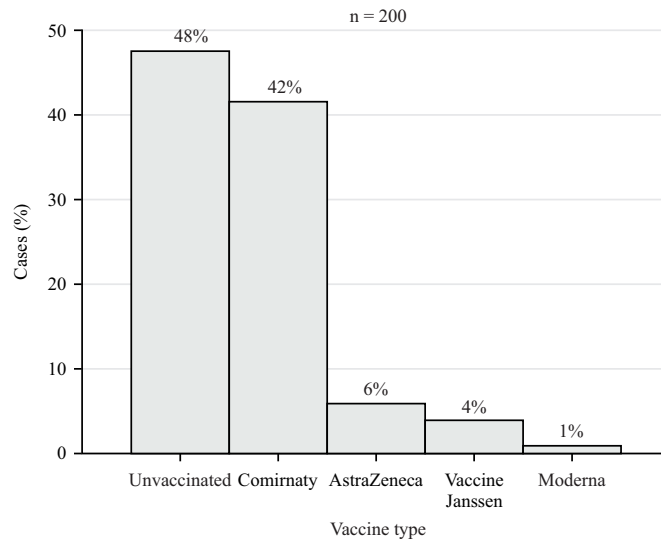


Fig. 5: Structure of patients according to the type of vaccine received

Table 4: ASA physical status classification system³

ASA PS classification	Definition	Adult examples, including, but not limited to
ASA I	A normal healthy patient	Individuals in good health, non-smokers, with minimal or no alcohol consumption
ASA II	A patient with mild systemic disease	Mild health conditions with no significant impact on daily functioning. This category includes current smokers, social drinkers, pregnant individuals, those with a Body Mass Index (BMI) between 30 and 40 (obesity) and individuals with well-controlled diabetes mellitus and hypertension or mild lung disease
ASA III	A patient with severe systemic disease	Individuals facing substantial functional limitations due to one or more moderate to severe health conditions. Examples include individuals with poorly controlled diabetes mellitus or hypertension, chronic obstructive pulmonary disease, morbid obesity (BMI ≥ 40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, end-stage renal disease undergoing regularly scheduled dialysis and a history (>3 months) of myocardial infarction, cerebrovascular accident, transient ischemic attack, or coronary artery disease/stents
ASA IV	A patient with severe systemic disease that is a constant threat to life	Individuals with recent (<3 months) myocardial infarction, cerebrovascular accident, transient ischemic attack, or coronary artery disease/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, shock, sepsis, disseminated intravascular coagulation, acute respiratory distress, or end-stage renal disease not undergoing regularly scheduled dialysis

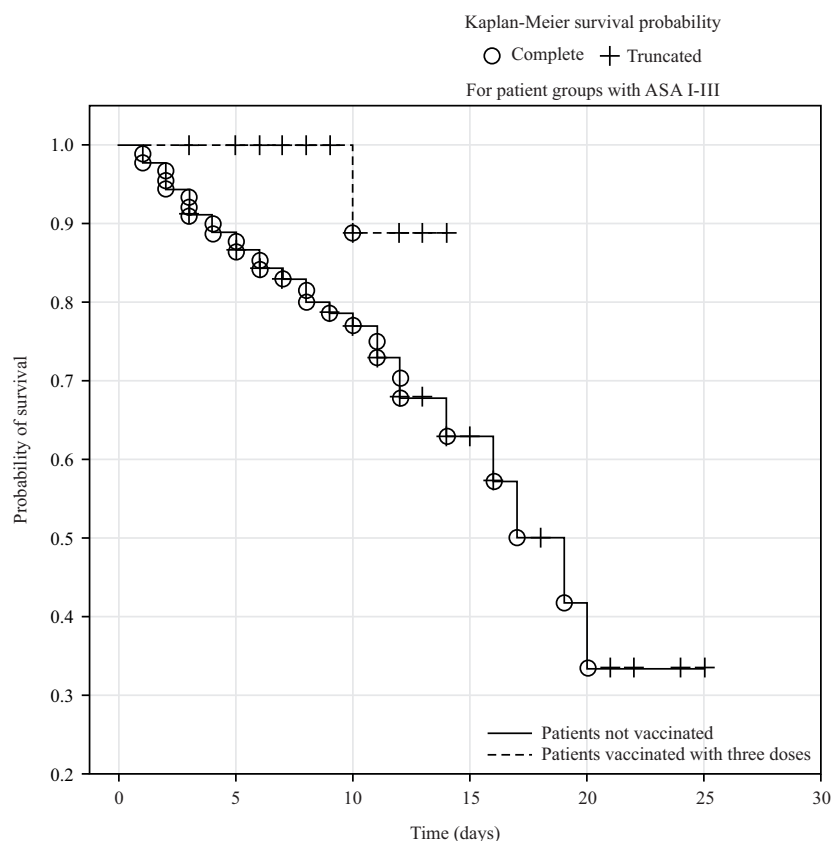


Fig.6: Cumulative (Kaplan-Meier) survival function plot for COVID-19 vaccinated and unvaccinated patient groups excluding ASA IV patients

six-point classification; however, all the patients in this study were graded from I to IV. We chose this patient qualification system because most anesthesiologists working in the COVID-19 ward and intensive care are specialists who use ASA in their daily work. The definitions and examples shown in the Table 4 were cited based on the original expert consensus documents of the American Society of Anesthesiologists³.

The median time to hospitalization (nine days in all patients) was similar to that observed in similar retrospective studies. For example, in the Warsaw study performed between March 2020 and April 2021 by Butkiewicz *et al.*⁴, the median was 10 days; in the Krakow study, it was 12 days, while Chinese researchers recorded 14 days. In summary, it can be assumed that a patient admitted to a "COVID" unit will stay there for 1.5-2 weeks⁴⁻⁷.

The present study showed that the median patient age was 69 years. More than half of the patients were male. Patients who did not survive were older by a median of 8 years than those who survived. Male patients did not account for a significantly higher proportion of patients who died than female patients. The overall mortality rate in the population

was 27%, with 4.5% of admissions requiring a higher level of support than that provided in a general medical ward.

The older patients had a higher risk of death than younger patients with COVID-19. Observations agree with a study by Cheng *et al.*⁸, which states that patients over 80 years of age have a 4.44-time higher risk of death than 60 year old patients. In this study, higher mortality was observed in men and Asians than in Caucasians⁸.

To the authors' knowledge, no studies have confirmed that the risk factors for severe disease and mortality among patients with COVID-19 are the same as those that determine assignment to different grades of the ASA scale. However, studies and meta-analysis have indicated that risk factors for mortality in patients with COVID-19 (obesity, hypertension, diabetes, cardiovascular disease, cancer and chronic obstructive pulmonary disease) enshrined in the ASA scales⁹⁻¹¹. However, this study was underpowered to prove with certainty that the ASA scale could be a good predictor of severity or mortality in patients infected with SARS-CoV-2. Although grade II ASA was associated with a lower risk of death, the value of the relative risk of death did not reach

statistical significance in the other groups. Similarly, only between grades II and III and grades II and IV according to ASA, differences in the number of deaths were found. A relationship between ASA and the degree of lung involvement due to COVID-19 changes was not found, which significantly influenced the risk of death. Otherwise, however, ASA would still be heavy for routine use, as it is not a scale commonly used by physicians of all specialties and indeed is reserved mainly for anesthesiologists.

A CT scan in isolation of other clinical parameters is not suitable as a screening tool for detecting COVID-19; however, in combination with epidemiological history, body temperature and leukocyte count, it can be helpful in efficiently identifying patients with suspected COVID-19 (the ETLC model)^{12,13}. However, chest CT has become an extremely helpful tool for quickly and objectively assessing the severity of lung involvement in patients with COVID-19 as well as to reflect the clinical course of the disease^{13,14}.

The severity of radiographic lung lesions was found to have a significant effect on patient mortality. The authors used unplanned statistical models to investigate the impact of patients' vaccination profiles on mortality, as a precaution against potential interpretive manipulation. This was particularly important in light of prevalent anti-vaccination movements. It is worth noting that the absence of statistically significant adjusted hazard ratio (aHR) values ($p < 0.05$) does not necessarily imply vaccine ineffectiveness. This fact has been confirmed by several large-scale studies on the efficacy of COVID-19 vaccines in reducing mortality rates¹⁵⁻¹⁸.

It is important to acknowledge, however, that this study has identified several limitations. The diminished number of individuals classified as ASA I and ASA IV, as well as the retrospective classification of patients into specific groups based on medical record descriptions, may have affected the analysis. However, this study provides valuable insights into the importance of patient classification and risk prioritisation in ward settings. Future research should explore optimal scales or indices for cohorting patients in wards, prioritising those at the highest risk of mortality. The interobserver agreement for CT scan assessments in the cited studies was high. However, the authors reported a Cohen's kappa of not 1.0, indicating that perfect agreement was not achieved. Therefore, it is possible that different radiologists describing the CT scans of the patients could have produced varying outcomes, which may have had a significant impact on the analysis. Furthermore, the absence of follow-up CT scans in the study groups hindered the investigation of changes in CT imaging features over time and their correlation with clinical and biochemical parameters in severe cases. The inclusion of such data would enhance disease progression management and

facilitate outcome prediction, thereby bolstering clinical decision-making processes¹⁹.

CONCLUSION

Increasing age and percentage of lung involvement in patients infected with COVID-19 were related to a higher inpatient mortality rate in the adjusted analysis. The ASA class II was associated with a lower risk of death. The ASA PS classification does not seem to be a good prospect for predicting the severity of COVID-19 or an increased risk of death during hospitalization. Routine chest computed tomography without contrast, together with the percentage assessment of radiological changes, turned out to be a good clinical practice because this index significantly influences the increase in mortality. Vaccinated patients had a lower chance of death during hospitalization and a higher chance of survival than patients not vaccinated against COVID-19.

SIGNIFICANCE STATEMENT

This research played a pivotal role in comprehending the nuanced characteristics of COVID-19 patients treated at the Provincial Specialist Hospital in Olsztyn. By analyzing a cohort of 200 individuals between November 28, 2021 and February 28, 2022, the current study aimed to uncover distinctive features and risk factors associated with the disease. The results illuminate the impact of various factors, such as age, ASA PS classification, structure of vaccination and the percentage of lung involvement by COVID-19, contributing valuable insights for enhancing patient care strategies. This contribution advances our understanding of COVID-19 outcomes within the specific context of our healthcare setting, offering essential information to guide future research and clinical practices.

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