Clinical characterization of hospitalized COVID-19 patients during the second wave of pandemic in the district of Rohrbach, Upper Austria

A single center retrospective study

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Received: 3 May 2021 / Accepted: 25 September 2021 / Published online: 21 October 2021
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Summary During the peak of the second wave of the coronavirus disease 2019 (COVID-19) pandemic in November 2020, the district of Rohrbach, Upper Austria, was reported to have had the highest 7-day incidence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) positive cases worldwide. In this study, we present the clinical characteristics of COVID-19 cases during the second wave of the pandemic in patients admitted to the only primary care hospital in the district of Rohrbach between October 2020 and February 2021. In total, 260 patients were hospitalized with a mean age of 72 years and a mortality rate of 14.6% and 13 patients (5%) were transferred to the intensive care unit (ICU). Critically ill patients (22.7%) were of older age and often lived in retirement and nursing facilities as compared to mild or moderately ill patients. Patients with a severe disease course showed significantly longer hospitalization, a worse peripheral oxygen saturation on admission and significantly higher levels of C-reactive protein (CRP), procalcitonin (PCT), lactate dehydrogenase (LDH), troponin I and D-dimer as compared to mild or moderate COVID-19 cases. These laboratory parameters might help to identify COVID-19 patients with a severe disease course. In conclusion, we could show that older, frail individuals are the most vulnerable group affected by COVID-19. Whether this trend in hospitalized patients continues with the persistence of the pandemic, the emergence of novel virus mutations, and the availability of several different vaccines is presently unclear and remains to be determined.

Keywords SARS-CoV-2 · Mortality · Laboratory features · Comorbidities · ARDS

Introduction

An unexplained pneumonia outbreak in Wuhan, China in late 2019 was detected by the Chinese authorities as having been caused by a new type of B-coronavirus [1]. This virus was named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and the World Health Organization (WHO) officially termed the disease caused by SARS-CoV-2 as coronavirus disease 2019 (COVID-19) [2]. COVID-19 rapidly spread from Wuhan to other cities in China and the entire world. By the end of February 2020, several European countries reported COVID-19 cases [3]. On 11 March the WHO officially declared the outbreak a pandemic, and governments across the world began implementing strategies to slow the infection spread, such as social distancing and complete lockdown [4]. Italy soon became the new emerging epicenter in Europe. In contrast to Italy and some other European countries, the first wave of the pandemic did not affect Austria as much as compared to the second wave.

During the first wave of the pandemic, the authorities reported 153 SARS-CoV-2 positive cases in the district of Rohrbach between March and May 2020 with
progression of the disease [11]. In patients with se-
described as cytokine storm in patients with a severe
tory mucosa triggering an immune response and in-
severe COVID-19 the development of acute respiratory
distress syndrome (ARDS) is characteristic and asso-
ciated with high mortality, approximately 40% of pa-
tients with ARDS do not survive [9].

The virus spreads and invades through the respira-
tory mucosa triggering an immune response and in-
duces a cytokine-release syndrome, which has been
described as cytokine storm in patients with a severe
progression of the disease [11]. In patients with se-
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tients with ARDS do not survive [9].

Computed tomography (CT) imaging is of utmost
importance for the diagnosis and prognosis of COVID-
19. The chest CT findings of COVID-19 may include
ground-glass opacities (GGO), crazy-paving pattern,
consolidation, and other findings of viral pneumonia
[12–14]. Chest CT can be used to evaluate the severity
of lung involvement. The CT findings are related to the
time course and often show different imaging signs
with progression [12].

In the early phase of the disease, there are multiple
interstitial changes, especially in the peripheral por-
tions of the lungs. In severe cases, lung consolidation
can occur, but pleural effusions are rare [12].

In the present study, we describe the clinical and
radiologic findings of COVID-19 patients admitted to
our hospital during the second wave of the pandemic
from October 2020 until February 2021, in which the
district was reported to have had the highest 7-day
incidence of SARS-CoV-2 positive cases worldwide
(1475 cases/100,000 inhabitants, 17 November 2020)
[15–17]. By 20 November 2020, 1196 SARS-CoV-2
positive individuals were reported to the authori-
ties in the district (2.1% of the population!) [18].
The 7-day incidence of SARS-CoV-2 positive cases
was 736/100,000 inhabitants in Upper Austria and
543/100,000 inhabitants all over Austria by that point
time.

Methods

Setting

This study was performed at the Klinikum Rohrbach,
the only primary care teaching hospital located in the
district of Rohrbach, Upper Austria. The hospital has
196 beds and provides basic medical and surgical care
with a department for internal medicine, a depart-
ment for surgery and for trauma surgery. The hospi-
tal also has a pediatric ward, a department for gyn-
ceology and obstetrics, a department of radiology and
a department for anesthesiology and intensive care
for an average of 11,000 inpatients (10,791 inpatients
in 2019) and 50,000 outpatients (49,436 outpatients in
2019).

Study design

We conducted a retrospective data analysis of the clinical
and demographic characteristics of all hospital-
ized COVID-19 cases during the second wave of pan-
demic admitted to our hospital between October 2020
and February 2021. The study was approved by the
Institutional Review Committee and all data were col-
clected retrospectively.

Data collection

The following data were collected from medical
records: patient characteristics, such as age, gen-
der, comorbidities (arterial hypertension, coronary
heart disease, diabetes mellitus, chronic obstructive
pulmonary disease), laboratory features (leukocytes,
lymphocytes, CRP, PCT, LDH, hypersensitive tro-
opin I, D-dimer), peripheral oxygen saturation on
admission, and length of hospitalization. Once a sus-
ppected case was admitted to the hospital, a nucleic
acid test (PCR, GeneXpert, Cepheid, Sunnyvale, CA,
USA) was carried out immediately by a nasopharyn-
geal swab and analysis in our laboratory to confirm
positivity for SARS-CoV-2. A native thin-section chest
CT was performed on every COVID-19 patient on
admission.

COVID-19 patients were clinically classified into
two major categories: first, mild disease course in
patients requiring no oxygen support, second, mod-
erate disease course in patients requiring oxygen
support, and, third, severe/critically ill patients with
either fatal outcome or survival and requirement of
high flow oxygen therapy (Airvo), continuous positive
airway pressure (CPAP) ventilation or invasive venti-
lation. We assessed the qSOFA score (respiratory rate,
altered mental status, systolic blood pressure) as well
as peripheral oxygen saturation and heart rate to de-
termine the degree of illness and to check for clinical
deterioration. Patients received additional treatment
with methylprednisolone, antibiotic therapy or an-
tithrombotic prophylaxis with low-molecular weight
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or moderately ill patients (74 years, 64–84 years IQR) (Table 1).

**Mortality**

The overall mortality rate of patients was 14.6% (38 of 260 patients) (Table 1), 59 patients (22.7%) were classified as severely/critically ill, 13 patients (5%) were transferred to the intensive care unit (ICU), 7 patients died on the ICU, 6 patients survived ICU and were transferred back to the normal medical ward and could be discharged later on. Of the COVID-19 patients with a critical condition 31 died on the normal medical ward and were not transferred to ICU due to high age and/or severe underlying comorbidities, 126 patients (48.5%) had a moderate disease course requiring additional oxygen support, whereas 75 patients (28.8%) showed a mild disease course requiring no oxygen therapy (Table 1).

**Laboratory findings and comorbidities of hospitalized COVID-19 patients**

Patients with a severe/fatal disease course showed significantly higher numbers of leukocytes (mean 7.1 G/L, 5.3–9.7 G/L IQR) as compared to patients...
with a mild (mean 6.2 G/L, 4.6–7.7 G/L IQR) or moderate disease course (mean 6.1 G/L, 4.5–8.5 G/L IQR) (Table 2). By contrast, patients with a severe/fatal disease course showed significantly lower numbers of lymphocytes (mean 0.7 G/L, 0.51–1.1 G/L IQR) as compared to patients with a mild (mean 1.0 G/L, 0.7–1.5 G/L IQR) or moderate disease course (mean 0.8 G/L, 0.6–1.1 G/L IQR) (Table 2). 

Patients with a severe/fatal disease course showed a significantly worse peripheral oxygen saturation on admission (mean 90.0%, 86.0–92.3% IQR) as compared to patients with a mild (mean 95.0%, 93.6–96.7% IQR) or moderate disease course (mean 92.0%, 89.2–94.0% IQR) (Table 2). In terms of laboratory findings on admission, patients with a severe/fatal disease course showed significantly higher levels of CRP, PCT, LDH, troponin I, and D-dimer, as compared to patients with a mild or moderate disease course (Table 2). We found no significant differences between the three COVID-19 patient groups regarding the frequency of medical comorbidities such as arterial hypertension, diabetes mellitus, coronary heart disease, or COPD. Overall, 60.8% of the patients had one or more of these comorbidities (Table 3).

**Discussion**

The district of Rohrbach, located in the northern part of Upper Austria, next to the border of Bavaria and the Czech Republic has a population of 56,545 people (November 2020). Rohrbach was reported to be the area with the highest 7-day incidence of SARS-CoV-2-positive cases worldwide during the second wave of the pandemic.

In this study we investigated all COVID-19 patients admitted to the Klinikum Rohrbach during the second wave of pandemic in a retrospective fashion. Overall, 260 patients were admitted, the mean age was 72 years, the overall mortality rate was 14.6% and 59 patients (22.7%) displayed a severe disease course with acute respiratory distress syndrome (ARDS) (Table 1). COVID-19 appeared mostly as typical viral pneumonia on thin-section chest CT, which was performed on every patient on admission. The disease was mainly distributed around the subpleural areas, predominantly in the lower lobes. Ground-glass opacities (GGO) were the most common imaging manifestation (Fig. 1).

In contrast to previously published reports, the mortality rate of COVID-19 patients transferred to our hospital was rather high. A significant proportion of fatal cases were not transferred to ICU due to high age and severe underlying comorbidities. Many of these old and vulnerable patients were transferred to the hospital from retirement/nursing homes and care facilities, in which COVID-19 clusters emerged during the second wave of the pandemic.

In terms of laboratory findings, we were able to show that hospitalized COVID-19 patients with a severe disease course had significantly higher levels of

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**Table 2** Laboratory features of hospitalized COVID-19 patients (n = 260)

| Total (n = 260) | Mild (n = 75) | Moderate (n = 126) | Severe/fatal (n = 59) | p-Value | Kruskal-Wallis H |
|----------------|-------------|-------------------|----------------------|---------|-----------------|
| Leucocytes (G/L) (4.0–10.0 G/L) | Mean (25–75% IQR) | Mean (25–75% IQR) | Mean (25–75% IQR) | Mean (25–75% IQR) | 0.028* | 7.148 |
| Lymphocytes (G/L) (0.6–5.0 G/L) | 6.2 (4.8–8.2) | 6.2 (4.6–7.7) | 6.1 (4.5–8.5) | 7.1 (5.3–9.7) | < 0.001*** |
| CRP (mg/L) (0.0–5.0 mg/L) | 0.8 (0.6–1.2) | 1.0 (0.7–1.5) | 0.8 (0.6–1.1) | 0.7 (0.51–1.1) | 0.001*** |
| PCT (ng/mL) (0.0–0.5 ng/mL) | 61.01 (23.44–118.08) | 24.25 (6.6–62.3) | 64.88 (31.03–118.34) | 107.56 (61.34–176.23) | < 0.001*** |
| LDH (U/L) (125–220 U/L) | 275 (208–348) | 213 (184–272) | 276 (213–325) | 398 (288–552) | < 0.001*** |
| D-dimer (mg/L) (0.0–0.49 mg/L) | 0.99 (0.55–2.17) | 0.76 (0.41–3.22) | 0.98 (0.59–1.91) | 1.41 (0.72–3.34) | 0.015* |
| Troponin I-HS (μg/L) (0.0–0.03 μg/L) | 0.01 (0–0.03) | 0.01 (0.0–0.01) | 0.01 (0.0–0.03) | 0.03 (0.01–0.07) | < 0.001*** |
| Peripheral oxygen saturation (SO2) (%) | 92.8 (90–95) | 95.0 (93.6–96.7) | 92.0 (89.2–94.0) | 90.0 (86.0–93.2) | < 0.001*** |

IQR inter-quartile range, CRP C-reactive protein, PCT procalcitonin, LDH lactate dehydrogenase, troponin I-HS hypersensitive troponin I

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**Table 3** Comorbidities of hospitalized COVID-19 patients (n = 260)

| Comorbidities (%)
|------------------|------------------|------------------|------------------|------------------|
| Total (n = 260) | Mild (n = 75) | Moderate (n = 126) | Severe/fatal (n = 59) | p-Value | χ²-test |
|----------------|-------------|-------------------|----------------------|---------|---------|
| Comorbidities (%) | Mean (25–75% IQR) | Mean (25–75% IQR) | Mean (25–75% IQR) | Mean (25–75% IQR) | 0.104 | 4.520 |
| Arterial hypertension (%) | 158 (60.8%) | 38 (50.7%) | 83 (65.1%) | 38 (64.4%) | 0.671 | 0.797 |
| Diabetes mellitus (%) | 132 (50.8%) | 35 (46.7%) | 67 (53.5%) | 30 (50.8%) | 0.148 | 3.822 |
| Coronary heart disease (%) | 38 (14.6%) | 6 (8%) | 21 (16.7%) | 11 (18.6%) | 0.060 | 5.344 |
| COPD (%) | 27 (10.4%) | 3 (4%) | 18 (14.3%) | 6 (10.2%) | 0.107 | 4.461 |

IQR inter-quartile range, COPD chronic obstructive pulmonary disease

*p < 0.05, ***p < 0.001

*Patients may have more than one comorbidity
CRP, PCT, LDH, troponin I, and D-dimer on admission as compared to mild or moderate cases. Similar findings have been published by Zhou et al., who postulated an 18-fold higher mortality for patients with D-dimer values greater than 1 µg/ml, as well as by Wang et al. who found significant higher values for leucocytes, D-dimer, LDH, GOT, GPT, and troponin I in ICU patients in comparison to non-ICU COVID-19 patients [19, 20].

Thus, such laboratory parameters in addition to measurement of the peripheral oxygen saturation in consideration of comorbidities might be of help to identify COVID-19 patients at risk of having a severe disease course, which is in accordance with previously published reports [21, 22].

The reasons why the district of Rohrbach displayed the highest 7-day incidence of SARS-CoV-2 positive cases worldwide in November 2020 during the peak of the second wave of the pandemic still remain unclear. One explanation for the high number of COVID-19 cases in this period of time might have been carelessness with respect to social distancing and a lack of adherence to lockdown sanctions.

Currently, there is still no specific drug for the treatment of patients with COVID-19. Some treatments suggest positive therapeutic effects for remdesivir, when given at an early time point of infection. Overall, 19 of our patients (7.3%) received remdesivir. In these patients, onset of clinical symptoms was shorter than 10 days [23, 24].

Our study has several limitations. First, this was a retrospective analysis and data were obtained from patient medical records, therefore, our data cannot be generalized or extrapolated. Second, the time frame of our observation period was rather short (4 months). At present (September 2021), Austria is approaching the fourth wave of the pandemic and the district of Rohrbach shows a 7-day incidence of SARS-CoV-2 positive cases of around 160 cases/100,000 inhabitants. Vaccination against COVID-19 is currently ongoing and most of the inhabitants in retirement/nursing homes in the district have already been vaccinated successfully or presumably died during the second wave of the pandemic. On the other hand, several new and more aggressive virus mutations have emerged.

In conclusion, our study showed that hospitalized COVID-19 patients during the second wave of the pandemic in the district of Rohrbach had a rather high mortality rate. Patients with a severe disease course were significantly older and had significantly higher CRP, PCT, LDH, troponin I, and D-dimer levels as compared to mild or moderate cases. Whether these trends in hospitalized patients continue with the persistence of the pandemic, the emergence of novel virus mutations, and the availability of several different vaccines is presently unclear and remains to be determined.

Acknowledgements We thank Renate Geretschläger, Florian Auburger, Günter Schwarz and Anna Hehenberger for skilful logistic and technical support.

Declarations

Conflict of interest K. Rosenberger, F. Pöschl, S. Geschev, K. Steiner, S. Puig, J. Röper-Kelmayr and K.J. Aichberger declare that they have no competing interests.

Ethical standards The study was approved by the Institutional Review Committee and all data were collected retrospectively.

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