Original Article

Barotrauma in patients with severe coronavirus disease 2019—retrospective observational study

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Background: Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus. Although it is known that the COVID-19 acute respiratory distress syndrome (ARDS) is associated with higher incidence of pulmonary barotrauma, unique mechanisms causing the aforementioned complication are still to be investigated. The goal of this research was to investigate the incidence of barotrauma among COVID-19 patients treated in the intensive care unit (ICU) and to examine different clinical outcomes among those subjects.

Methods: This retrospective observational cohort study included adult COVID-19 patients admitted to ICU from September 1, 2020, to February 28, 2022. All admitted subjects received invasive respiratory support. Subjects were divided into two groups based on occurrence of pulmonary barotrauma. Data were collected from available electronical medical records.

Results: In the study period, a total of 900 subjects met inclusion criteria. Pulmonary barotrauma occurred in 88 (9.8%) of them. Subcutaneous emphysema developed in 73 (83%), pneumomediastinum in 68 (77.3%) and pneumothorax in 54 (61.4%) subjects. A small group of subjects developed less common complications like pneumoperitoneum (8 subjects, 9.1%) and pneumopericardium (2 subjects, 2.3%). Survival rate was higher in control than in barotrauma group [396 (48.8%) *vs.* 22 (25.0%), P<0.05]. There was also a significant difference between two groups in PaO_2/FiO_2 ratio on admission, duration of non-invasive respiratory support before mechanical ventilation, duration of mechanical ventilation and duration of ICU and hospital stay, all in favour of control group.

Conclusions: Development of barotrauma in patients with severe forms of COVID-19 disease and in need of respiratory support is associated with longer ICU and hospital stay as well as lower survival rates at hospital discharge. Further efforts are needed in understanding mechanism in developing barotrauma and finding new prevention and treatment options.

Keywords: Coronavirus disease 2019 (COVID-19); intensive care unit (ICU); positive pressure ventilation; barotrauma; ventilator induced lung injury (VILI)

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Introduction

Due to the extremely rapid spread of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus, the World Health Organization declared a state of emergency at the beginning of 2020, and the official start of the pandemic in March 2020 (1). Symptoms of infection varied from asymptomatic or mild forms of the disease to severe acute respiratory syndrome (2). Severe forms of infection caused acute respiratory distress syndrome (ARDS) and required mechanical ventilation and treatment in intensive care units (ICUs) (3,4).

Acute respiratory distress syndrome is defined as an acute disorder characterized by bilateral lung infiltrates and severe progressive hypoxemia with no evidence of cardiogenic pulmonary edema (4). The definition of ARDS was updated in 2012 and is called the Berlin definition (5,6). Therapy is mainly supportive and includes ventilatory support, prone positioning, sedation, muscle relaxation, fluid management and in some cases extra corporeal membrane oxygenation (ECMO) (7). SARS-CoV-2 infection can be confirmed by positive detection of viral RNA using a specific polymerase chain reaction (PCR) test. Coronavirus disease 2019 (COVID-19) illness, on the other hand, can be confirmed by a consistent clinical history, epidemiological anamnesis and a positive SARS-CoV-2 PCR test. COVID-19 ARDS is diagnosed when someone with confirmed COVID-19 illness meets the Berlin 2012 ARDS diagnostic criteria (8).

In the initial period of the pandemic, due to limited resources and limited number of intensive care unit nurses and physicians, as well as limited number and availability of mechanical ventilators, attempts were made for non-invasive respiratory support [high flow nasal oxygenation (HFNO), continuous positive airway pressure (CPAP) masks] (9). Invasive methods of ventilation were considered to be one of the last steps of treatment (10). This approach proved to be successful in a certain number of patients. As the new treatment recommendations and guidelines emerged, and more nurses and physicians were trained and educated to work in intensive care units, the emphasis was placed on timely intubation of the patient and treatment with invasive mechanical ventilation (11,12).

During the pandemic, majority of the patients treated in our ICU had severe form of ARDS as part of SARS-CoV-2 infection (PaO_2/FiO_2 <100 mmHg) (6). In a certain number of patients, complications of respiratory support occurred as a result of barotrauma resulting in subcutaneous emphysema, pneumothorax, pneumomediastinum, and less often pneumopericardium and pneumoperitoneum. Most common cause of pulmonary barotrauma is regional lung overdistention which is a key factor for ventilator induced lung injury (VILI) (13,14). VILI can also be caused by volutrauma, atelectotrauma and biotrauma (14). VILI is mostly seen in patients treated for ARDS, but taking into account that manifestations of VILI are very similar to the ones that appear in ARDS, true incidence of VILI is unknown (15). Patients suffering from ARDS caused by COVID-19 virus are more susceptible to pulmonary barotrauma than the patients suffering from ARDS caused by other factors (16,17).

Although the incidence of pulmonary barotrauma is much higher in patients on invasive respiratory support, there is also chance of developing barotrauma in patients on non-invasive respiratory support (16).

It was reported that aforementioned pulmonary barotrauma complications can significantly affect the final outcome of the treatment and patients mortality (17).

The goal of this research was to investigate the incidence of barotrauma among subjects with COVID-19 disease treated in the ICU and to examine different clinical outcomes among those subjects. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-677/rc).

Highlight box

Key findings

- Patients who developed barotrauma spent longer time on invasive ventilation and had longer intensive care unit (ICU) and hospital stay. They also had significantly lower survival rate at hospital discharge.

What is known and what is new?

- Pulmonary barotrauma is a relatively common complication in patients treated with mechanical ventilation. It is important to recognize it on time but also act to prevent it from happening.
- Severe acute respiratory syndrome coronavirus 2 virus manifests itself in a wide spectrum of simptoms including acute respiratory distress syndrome (ARDS). In severe cases of ARDS most important treatment is mechanical ventilation, amongst other supportive measures. As a complication of positive pressure ventilation, pulmonary barotrauma can affect mortality as well as ICU and hospital stay.

What is the implication, and what should change now?

- Coronavirus disease 2019 ARDS is a condition that has not been fully understood, but as time goes by and we start to understand this syndrome better, we will be able to adapt treatment to reduce barotrauma complications.

Methods

This was a retrospective observational cohort study. The study was conducted in the Intensive care unit of University Hospital Split, Croatia. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethical board of University Hospital Split, Croatia (class 500-03/22-01/89, registration number: 2181-147/01/06/M.S.-22-02, Split, Croatia, 14 June 2022) and individual consent for this retrospective analysis was waived.

Patients

All patients older than 18 years with confirmed COVID-19 disease who were admitted to the ICU between September 1, 2020, to February 28, 2022 were eligible for inclusion. Laboratory confirmation of SARS-CoV-2 virus was defined as a positive result of real-time reverse transcriptase-polymerase chain reaction (RT-PCR) assay of naso-pharyngeal swab. Inclusion criteria was duration of mechanical ventilation >24 h.

For the purpose of this study, subjects on non-invasive respiratory support were defined as those who were treated with high flow nasal cannula (HFNC) or CPAP masks. Invasive respiratory support was defined as intubation and mechanical ventilation.

All subjects on mechanical ventilation treated in our ICU were treated following the principles of lung-protected ventilation. That included tidal volumes limited to 4–8 mL/kg, targeted plateau pressure (Pplat) was <30 cmH_2O with driving pressure <15 cmH_2O. Positive end expiratory pressure (PEEP) was applied (starting with 10 cmH_2O), depending on the subjects characteristics and modified as needed. Continuous sedation and intermittent muscle relaxation were also administered. In cases where ventilation targets could not be achieved during first hours after ICU admission despite the described measures, patients were ventilated in prone position for at least 12 h. Contraindications for prone positioning were recent cardiac, abdominal or thoracic surgery, burns, pregnancy, unstable fractures and spinal instability.

Subjects who were readmitted to the ICU, subjects who spent less than 24 hours in the ICU and those who developed barotrauma before ICU admission were excluded from the study.

Outcomes

The primary outcome of this research was the incidence of pulmonary barotrauma during treatment with mechanical ventilation of COVID-19 subjects treated in the ICU.

Secondary outcomes were survival at discharge from the hospital, number of days spent on mechanical ventilation, number of days spent in ICU and total number of days spent in hospital. Barotrauma was defined as presence of subcutaneous emphysema, pneumothorax, pneumomediastinum, pneumocardium or pneumoperitoneum. The diagnosis was confirmed by clinical and radiological examinations [chest X-ray, chest computed tomography (CT), ultrasound].

Data collection

Data were collected from available electronical medical records. It included demographic data (age, gender, comorbidities), PaO_2/FiO_2 ratio on admission, type and duration of respiratory support before admission to the ICU, type and duration of respiratory support during the ICU stay, incidence of barotrauma and survival at the hospital discharge. Data extraction and collection was performed by several authors. Before the start of the study, all authors were trained and pilot data extraction was done in order to ensure consistency in data collection and recording.

PaO_2/FiO_2 ratio was calculated by dividing pO_2 from arterial blood gas analysis with fraction (percent) of O_2 that subject was receiving. PaO_2/FiO_2 ratio is expressed in mmHg. Duration of respiratory support is expressed as number of days the subject spent on respiratory support. Incidence of barotrauma was calculated as a ratio of subjects who presented with some form of barotrauma among all subjects treated in the ICU and included in this study. Survival at hospital discharge was calculated as ratio of subjects who were discharged alive from hospital among all patients from analyzed group (barotrauma or control).

Statistical analysis

Data were compared between the subjects who developed pulmonary barotrauma complications (barotrauma group) and those who did not develop barotrauma (control group).

Descriptive statistics was used for demographic data. For continuous data, median and interquartile range (IQR) were reported. Mann-Whitney *U* test or Chi-squared tests were used for group comparisons as appropriate. Multivariate analysis and logistic regression was used for outcome analysis. P value of less than 0.05 was considered statistically

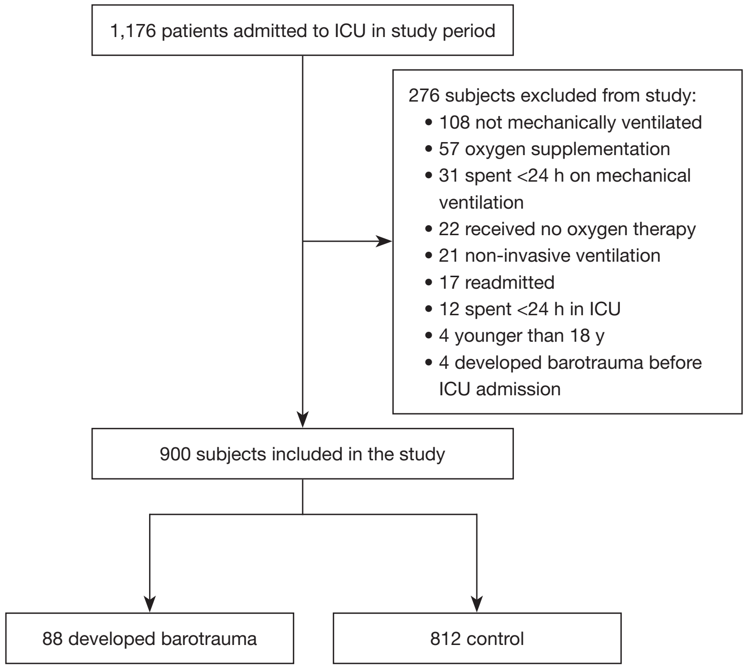

Figure 1 Study flowchart. ICU, intensive care unit.

significant. Data were analysed using GraphPad Prism version 9.0.0 for Windows, GraphPad Software, San Diego, CA, USA.

Results

From September 1, 2020 to February 28, 2022, a total of 1,176 subjects diagnosed with COVID-19 were treated in the ICU in our institution. Of those, 900 met inclusion criteria and were included in this study. Flowchart is presented in *Figure 1*. Of all subjects treated with positive pressure ventilation (PPV), 88 (9.8%) of them developed some type of pulmonary barotrauma complication. The median age of this cohort was 68 years (IQR, 60–74 years); of those, 56 were males (63.6%). Median duration of respiratory support before barotrauma diagnosis was 8 days (IQR, 3–12 days).

The most common complication was subcutaneous emphysema which developed in 73 (83%) subjects. Pneumomediastinum occurred in 68 (77.3%) and pneumothorax in 54 (61.4%) subjects. A small group of subjects developed less common complications like pneumoperitoneum (8 subjects, 9.1%) and pneumopericardium (2 subjects, 2.3%). Regarding diagnostics, chest CT was the primary option for radiological confirmation (54 subjects, 61.4%) followed by chest X-ray, ultrasound and clinical manifestations (34 subjects, 38.6%).

Five subjects with barotrauma underwent surgical treatment (5.7%) while others were treated conservatively. Twenty-three subjects (26.1%) from barotrauma group had tracheostomy.

Demographic data are presented in *Table 1*.

The majority of subjects needed some form of respiratory support before the admission to ICU, 94.2% in control group and 98.9% in barotrauma group. Sixty-four patients (72.7%) from barotrauma group received HFNC and 2 patients (2.3%) were on CPAP prior to ICU admission. In control group, 546 patients (67.2%) were on HFNC and 21 patients (2.6%) were on CPAP prior to ICU admission. There was no difference between two groups regarding the type of non-invasive respiratory support before mechanical ventilation. There was also no difference in the number of times that subjects were ventilated in prone position as well as in the average duration of pronation.

Regarding the survival, 418 (46.4%) subjects were alive at the hospital discharge. Subjects from control group had better survival rate (48.8%) than barotrauma group (25.0%) ($P<0.05$).

There was a significant difference between two groups in PaO_2/FiO_2 ratio on admission, duration of non-invasive

Table 1 Demographic data

Parameters	All patients	Barotrauma	Control	P value
Number of patients	900 (100.0)	88 (9.8)	812 (90.2)	
Age (years)	67 [60–74]	68 [60–74]	67 [59–74]	0.47
Gender				
Male	632 (70.2)	56 (63.6)	673 (82.9)	<0.05
Chronic pulmonary disease	84/895 (9.4)	8/88 (9.1)	76/807 (9.4)	0.92
Asthma	17/84 (20.2)	3/8 (37.5)	14/76 (18.4)	0.27
COPD	37/84 (44.0)	1/8 (12.5)	36/76 (47.4)	0.14
Asbestosis	7/84 (8.3)	1/8 (12.5)	6/76 (7.9)	0.69
Carcinoma	10/84 (11.9)	–	10/76 (13.1)	0.3
OSA	5/84 (6.0)	2/8 (25.0)	3/76 (4.0)	0.02
Other	8/84 (9.5)	1/8 (12.5)	7/76 (9.2)	0.79
Respiratory support before ICU admission	852/900 (94.6)	87/88 (98.9)	765/812 (94.2)	0.07
HFNC	610/900 (67.8)	64/88 (72.7)	546/812 (67.2)	0.18
CPAP	23/900 (2.6)	2/88 (2.3)	21/812 (2.6)	0.86
Face mask/nasal catheter	187/900 (20.8)	20/88 (22.7)	167/812 (20.1)	0.64
Mechanical ventilation	32/900 (3.6)	1/88 (1.1)	31/812 (3.8)	0.2
No support	5/900 (0.6)	–	5/812 (0.6)	0.46
Unknown	43/900 (4.8)	1/88 (1.1)	42/812 (5.2)	
Pronation	631/900 (70.1)	58/88 (65.9)	573/812 (70.6)	0.36
0	357/900 (39.7)	30/88 (34.1)	327/812 (40.3)	0.26
1	237/900 (26.3)	17/88 (19.3)	220/812 (27.1)	0.12
2	186/900 (20.7)	18/88 (20.5)	168/812 (20.7)	0.96
3	112/900 (12.4)	10/88 (11.4)	102/812 (12.6)	0.75
Barotrauma		88/900 (9.8)		0.19
Pneumomediastinum		68/88 (77.3)		
Pneumothorax		54/88 (61.4)		
Subcutaneous emphysema		73/88 (83.0)		
Pneumoperitoneum		8/88 (9.1)		
Pneumopericardium		2/88 (2.3)		
Radiological confirmation				
MSCT		54/88 (61.4)		
Chest X-ray		34/88 (38.6)		
Surgical treatment		5/88 (5.7)		
Tracheotomy		23/88 (26.1)		

Data are presented as n (%), median [IQR], or n/N (%). COPD, chronic obstructive pulmonary disease; OSA, obstructive sleep apnea; ICU, intensive care unit; HFNC, high flow nasal cannula; CPAP, continuous positive airway pressure; MSCT, multi-slice computed tomography; IQR, interquartile range.

Table 2 Secondary outcomes

Outcomes	All patients	Barotrauma	Control	P value
Survival at hospital discharge	418/900 (46.4)	22/88 (25.0)	396/812 (48.8)	<0.05
Duration of non-invasive respiratory support before mechanical ventilation (days)	1 [0.04–2]	1 [0.09–3]	1 [0.03–1.6]	<0.05
PaO_2/FiO_2 at ICU admission	78 [62–96]	65 [54–84]	80 [64–97]	<0.05
Mechanical ventilation (days)	8 [5–14]	16 [8–22]	8 [5–13]	<0.05
Average duration of pronation (hours)	17 [16–23]	16 [16–22]	17 [16–23]	0.11
Total duration of pronation (hours)	32 [21–48]	38 [24–63]	32 [20–48]	0.3
Days in ICU	10 [7–16]	19 [11–27]	10 [6–15]	<0.05
Days in hospital	20 [14–30]	23 [17–36]	19 [14–29]	<0.05

Data are presented as n/N (%) or median [IQR]. ICU, intensive care unit; IQR, interquartile range.

respiratory support before mechanical ventilation, duration of mechanical ventilation and duration of ICU and hospital stay, all in favour of control group. These results are presented in *Table 2*.

In multivariate analysis, only ICU length of stay (LoS) was associated with increased incidence of barotrauma, while other factors (mechanical ventilation, PaO_2/FiO_2 ratio, hospital LoS, age and gender) did not show correlation with barotrauma.

In survival analysis, age [odds ratio (OR) 0.98, 95% confidence interval (CI): 0.966 to 0.998], duration of non-invasive respiratory support before mechanical ventilation (OR 0.67, 95% CI: 0.533 to 0.825), duration of mechanical ventilation (OR 0.776, 95% CI: 0.713 to 0.837) and duration of ICU (OR 1.07, 95% CI: 1.002 to 1.16) and hospital stay (OR 1.09, 95% CI: 1.064 to 1.123) were associated with survival at hospital discharge. Other factors (gender, PaO_2/FiO_2 ratio on admission, duration of prone position ventilation and barotrauma occurence) were not associated with survival.

Discussion

Among 900 COVID-19 patients treated in ICU, 9.8% developed some form of barotrauma due to mechanical ventilation. In our cohort, barotrauma was associated with longer duration of mechanical ventilation, longer ICU and hospital length of stay and lower survival at hospital discharge.

In our institution there was a large inflow of SARS-CoV-2 infected patients throughout the whole pandemic. Patients with milder forms of COVID-19 disease were treated in hospital wards and those with severe COVID-19 disease accompanying severe forms of ARDS were treated in the ICU. Considering large number of patients treated in the ICU, there was a real challenge to maintain the level of intensive care that they demanded. In the first wave of the pandemic there was room for more extensive treatments and all types of respiratory support. Both invasive and non-invasive ventilation were used as a therapy in the ICU. As the number of patients requiring more complex treatment grew larger, ICU became the place for patients who needed exclusively invasive mechanical ventilation. Due to limited intensive care staff, nurses and physicians, and due to limited number of intensive care beds available, non-invasive respiratory support became standard treatment in other hospital wards before admission to ICU. As the number of patients grew larger, so did the percentage of complications arising as a result of the administered treatment. One of those complications were pulmonary barotrauma related complications which included pneumothorax, pneumomediastinum, pneumopericardium, pneumoperitoneum and subcutaneous emphysema.

Literature reports incidence rate of pulmonary barotrauma in mechanically ventilated COVID-19 patients varying from 3.6% to 40% (17-19). The reported incidence is higher than the incidence of barotrauma in patients with ARDS not related to COVID-19 (3% to 15%) (20,21). When ARDS occurs due to other etiology, lung injury is proportional to severity of the illness, level of lung edema and the capacity of the lung for gas exchange (22,23). On the other hand, COVID-19 ARDS is a sum of several complex pathophysiological mechanisms such as excessive inflammatory response and changes on cellular level (dysregulation of ACE2 receptors) (22,23). The incidence of barotrauma in our study was lower than those reported in case control study by Udi *et al.* and retrospective cohort study by Kahn *et al.* (19,24). On the other hand, Venkateswaran *et al.* showed lower incidence of barotrauma complications in patients who were treated with invasive mechanical ventilation than the one we presented in this study (18). However, in their study, 41% of ICU patients were mechanically ventilated and there is no data on disease severity of their patients (18).

Most common barotrauma complication in our study was subcutaneous emphysema. Same was observed in other studies (25,26). The second most common barotrauma complication in our study was pneumomediastinum which developed in 77.3% of patients. Despite the large share of patients with pneumomediastinum, only a few of them required surgical treatment. Same was reported in series of cases by Patel *et al.* (27). Most pneumomediastinums resolved spontanously, without any influence on hemodinamics. In few cases pneumomediastinum developed spontaneously in patients without PPV or even oxygen therapy, which started to raise questions if COVID-19 pneumonia had more severe impact on respiratory system than we thought (28). The third most common barotrauma complication was unilateral pneumothorax. The incidence of pneumohorax in our patients was lower than the one presented in the systematic review (17). Large number of patients who developed pneumothorax as a complication needed chest drains. In many cases there were combinations of previously mentioned barotrauma complications in the same patient. Only a few patients developed pneumopericardium or pneumoperitoneum. Percentage of chronic pulmonary diseases was low in barotrauma group (9.1%), even lower than in control group (9.4%). Most common chronic pulmonary disease in patients with pulmonary barotrauma was asthma. Same was reported in study conducted by Elsaaran *et al.* (29). Both Elsaaran *et al.* and Tetaj *et al.* found no significant increase in the incidence of barotrauma complications in patients with chronic pulmonary diseases (29,30).

Our study showed a significant increase in ICU and hospital length of stay, as well as trend toward an increased duration of ventilatory support in barotrauma group. Furthermore, there was a significant difference in survival rate at hospital discharge in favour of control group. Similar results were reported by other studies. Khan *et al.* found significant increase in ICU length of stay and hospital length of stay, as well as increased duration ventilatory support (24). However, there was no statistically significant correlation between pulmonary barotrauma and mortality (24). Belletti *et al.* analyzed 116 mechanically ventilated severe COVID-19 patients. They reported significant difference in length of ICU and hospital stay in favour of patients who did not develop pneumothorax or pneumomediastinum compared to those who did develop these complications (31). On the other hand, Elsaaran *et al.* found no significant difference in hospital and ICU stay between the barotrauma group and the group that did not develop barotrauma complications but the mortality rate was significantly higher in barotrauma group (29). In our study, median time from ICU admission to the development of barotrauma was 8 days. In comparison, Abdallat *et al.* report median time of 3.5 days between start of mechanical ventilation and development of barotrauma, while Udi *et al.* observed development of barotrauma on the eighteenth day of mechanical ventilation (19,32). Other studies also report development of pulmonary barotrauma in the second week of mechanical ventilation (29,31). Prior to this pandemic, prone positioning was well known therapeutic measure for ARDS, but it became more common procedure in COVID-19 ARDS in the absence of other targeted therapy. A systemic review by Chua *et al.* showed improved PaO_2/FiO_2 ratio with better SpO_2 in prone positioned patients with COVID-19 ARDS (33). Our results did not show difference in frequency or duration of prone positioning between two groups. This was not surprising, considering that patients from both groups had severe forms of ARDS with PaO_2/FiO_2 ratio on admission under 100 mmHg. Guven *et al.* reported longer duration in prone position for patients in barotrauma group. The main indication for prone positioning in their cohort was PaO_2/FiO_2 ratio under 150 mmHg (34).

A study conducted by Chávez *et al.* showed that lower PaO_2/FiO_2 ratio was associated with increased incidence of barotrauma (35). Most of our patients had PaO_2/FiO_2 ratio under 100 mmHg on admission indicating that patients had developed severe form of ARDS. There was also a significant difference between the two groups with lower values in barotrauma group. In multivariate analysis, however, lower PaO_2/FiO_2 ratio was not associated with barotrauma. Regarding the survival at hospital discharge, barotrauma patients had significantly lower survival rate than control group. Our findings correlated with the findings presented in the systematic review by Shrestha *et al.* They analyzed 13 studies that reported in-hospital mortality and showed significantly higher mortality rate in patients who developed some kind of barotrauma complication (17).

Since the incidence of barotrauma is higher in COVID-19 related ARDS despite the use of protective ventilation protocols, it is possible that SARS-CoV-2 infection induces damage to the lung parenchyma making them more susceptible to developing complications during mechanical ventilation (36,37). The lung damage induced by SARS-CoV-2 infection can lead to development of barotrauma not only in mechanically ventilated but also in spontaneously breathing patients (38). Vetrugno *et al.* showed in their multicenter study that non-invasive ventilation was associated with increased incidence of barotrauma, same as mechanical ventilation (37). HFNC, on the other hand, was not associated with barotrauma development. Same authors report increased incidence of barotrauma in patients who received an escalation of respiratory support, meaning that there was increased risk of barotrauma if patients received more than one form of non-invasive respiratory support (37).

In order to reduce the risk of treatment related complications, recognizing the patients at risk is of great importance. One of the factors that proved reliable is so-called Macklin effect (39). It has been shown that patients with this sign on baseline CT imaging are at high-risk for barotrauma development (40).

Considering all the data and increased susceptibility to complications related to respiratory support, it seems reasonable not to delay intubation and mechanical ventilation in patients with COVID-19 ARDS in cases where non-invasive support did not reach its goals, especially in patients with increased risk of barotrauma development (38,40). Furthermore, patients on mechanical ventilation could benefit from even more protective ventilator settings than those suggested by current guidelines (36,38). A further reduction of barotrauma risk could be achieved by early institution of ECMO in selected patients (38). Our study had some limitations. First, this was a single-center retrospective observational study which limits the applicability of results. Another limitation is the lack of detailed information about ventilation parameters which were not available in electronical medical records and due to limited resources, we were unable to extract those data from paper records. Therefore, we were unable to analyze relationship between ventilator parameters and barotrauma. However, since guidelines for protective ventilation were followed from the beginning of pandemic, we expect that no difference would be observed between the two groups in terms of ventilation parameters.

Unfortunately, due to continuous inflow of patients to our ICU during the pandemic, and since that there is no objective way to precisely distinguish different waves and to analyze subjects from each wave separately, we have analyzed our subjects all together. Therefore, we were unable to compare outcomes between different pandemic waves. Furthermore, since the X-ray was not done routinely on daily basis, it is possible that delay in diagnosing some cases of barotrauma occurred. However, since all patients were regularly checked couple of times a day, and since X-ray was done in case of any suspicion on barotrauma, we believe that this delay did not occur often.

In order to improve future research, a multicenter studies would be more valuable as it would increase applicability of results. Furthermore, instituting an electronical medical records in ICU would be beneficial since we were unable to analyze valuable data as those were not available in electronical form.

Conclusions

In this retrospective, single-center observational study we analyzed the incidence of pulmonary barotrauma as a complication of respiratory support in COVID-19 patients and its association with hospital stay and mortality. Overall incidence of barotrauma complications was 9.8%. Patients who developed barotrauma spent longer time on invasive ventilation and had longer ICU and hospital stay compared to control group. They also had significantly lower survival rate at hospital discharge.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-677/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-677/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.

com/article/view/10.21037/jtd-23-677/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethical board of University Hospital Split, Croatia (class 500-03/22-01/89, registration number: 2181-147/01/06/M.S.-22-02, Split, Croatia, 14 June 2022) and individual consent for this retrospective analysis was waived.

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