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Management of protective lung ventilation in children with a critical course of acute respiratory distress syndrome caused by SARS-CoV-2 coronavirus infection

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Abstract: *the pandemic of coronavirus disease COVID-19 has created a serious threat to the public health system worldwide. With the beginning of the pandemic, it became clear that children infected by SARS-CoV-2, for unknown reasons, have a milder course compared to adults. In some cases, children are asymptomatic carriers of the infection. In light of today's scientific discoveries, contrary to initial reports, recent studies have shown that children are just as likely to contract the virus as adults, while vague symptoms and a milder course more often characterize the disease itself. However, it is worth noting that the true prevalence of asymptomatic SARS-CoV-2 infection is most likely underestimated since children are not tested for COVID-19 without obvious clinical symptoms. This fact has been confirmed by multiple blood tests indicating high titers of IgG to SARS-CoV-2. Compared to adults, the typical clinical manifestations of COVID-19 in children are fever, runny nose, cough, and general weakness. The laboratory test results indicate a normal level of leukocytes, lymphopenia, and an increased level of aspartate aminotransferase, alanine aminotransferase, D-dimer, and MB creatine kinase. Currently, there is no sufficient evidence that the etiotropic therapy is 100% successful. Yet a course of action such as respiratory system protection, control of fluids and electrolyte homeostasis, anti-cytokine therapy, preventative measures for thrombosis, and treatment for bacterial superinfection proved to be efficient at preventing the development of possible complications caused by SARS-CoV-2. Therefore, it is important to collect and accumulate new experiences\cases of respiratory system protection management of an acute respiratory syndrome with a critical course of acute respiratory distress syndrome caused by COVID-19 and implement practical treatment plans for healthcare facilities. The results were analyzed using clinical epidemiology methods. Children were admitted to the intensive care unit on an average of 6,6±0,62 days of illness and were more associated with systemic disorders and water-electrolyte imbalance, which required prosthetic respiratory function, correction of hemodynamics and water-electrolyte disorders, which was carried out in the infectious diseases department of anesthesiology and intensive care for an average of 5,2±0,7 days. In children in the clinical group, SARS-CoV-2 was verified by reverse transcription polymerase chain reaction of a nasopharyngeal swab and/or exhaled air condensate based on its positive results. Comprehensive treatment of patients with severe and extremely severe respiratory distress syndrome in coronavirus disease included respiratory and hemodynamic support, antiviral and antibacterial therapy, parenteral glucocorticosteroids and anticoagulants, which was in line*

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with current national regulatory guidelines and local protocols. According to the criteria for choosing a method of respiratory function prosthetics, in more than half of the patients (62,2%) with hemoglobin oxygen saturation of less than 92%, while maintaining active respiratory capacity, respiratory support was provided by supplementing humidified oxygen through a face mask or nasal cannulas. In another 29,7% of patients, non-invasive ventilation was performed by constant positive airway pressure, with an oxygenation index of 0,4-0,5 and a positive end-expiratory pressure of 4-5 cm of water column. Children who had a critical course of acute respiratory syndrome caused by coronavirus infection COVID-19 (8,1%) and in whom non-invasive methods of respiratory support did not bring the desired therapeutic result were on invasive ventilation in the mode of auxiliary controlled ventilation or in the mode of synchronized intermittent forced ventilation. It should be noted that children who received respiratory support in the form of non-invasive ventilation by means of constant positive airway pressure required a lower concentration of oxygen in the inhalation mixture compared to patients on free-flow oxygen supplementation. The need for admission to the intensive care unit of children with COVID-19 is primarily associated with respiratory disorders caused by interstitial pneumonia. Oxygen supplementation was of paramount importance in patient management, primarily through noninvasive ventilation with constant positive airway pressure or free flow. The use of a pulmonary protective strategy in the treatment of acute respiratory distress syndrome caused by coronavirus disease COVID-19 in children requiring invasive ventilation was accompanied by a pronounced positive result, as it was not accompanied by side effects and resulted in a rapid recovery of patients.

Keywords: Children; Pneumonia; COVID-19; Intensive Care Unit; Respiratory System Protection, respiratory distress.

Introduction

The unprecedented case of the new coronavirus (COVID-19) pandemic has caused significant spread worldwide and a crude death rate. The most common complex of symptoms encountered in the pediatric population were fever, gastrointestinal disorders, rash, conjunctival injection, and respiratory disorders (Dufort E. M., Koumans E. H., 2020; Davies P., Evans C., 2020; Kaushik A., Gupta S., 2020; Aronoff S., Advani S., 2020; Dhanalakshmi A., 2020; Williams V., Dash N., 2020). The leading nosological forms in children requiring admission to the pediatric clinic, in particular, the intensive care unit, were pneumonia, acute respiratory distress syndrome, as well as multiorgan dysfunction syndrome and multisystem inflammatory syndrome (MIS-C) (Williams V., Dash N., 2020).

RDS is one of the manifestations of an acute respiratory infection, in particular, in the course of the infectious-inflammatory process caused by the RNA viral SARS-CoV-2, which has a tropism for respiratory alveolocytes, which determines the severity of the condition (Aguilar-Caballero D., Capcha J. M. C., 2023). Unlike adults, children have a milder course of COVID-19 in general for unknown reasons. It is likely that children are less affected by the SARS-CoV-2 virus due to lesser expression levels of angiotensin-converting enzyme type 2. This case is supported by the fact that adult patients, who required treatment in the intensive care unit, had higher levels of cytokines, while children with COVID-19 revealed a lower degree of immune dysregulation (Gu H., Xie Z., 2016).

A unique challenge of the coronavirus disease COVID-19 was the emergence of multisystem inflammatory syndrome in children, a rare post-infectious hyperinflammatory disorder associated with SARS-CoV-2. MIS-C is characterized by predominant systemic inflammation, fever, hypotension, and cardiac dysfunction. Unfortunately, mortality from MIS-C is rare and does not require respiratory protection (Patel J. M., 2022).

Children that were admitted to the intensive care unit with a positive laboratory test for SARS-CoV-2 had signs of respiratory disorder, often requiring respiratory support, which requires different techniques including standard oxygen therapy via nasal cannula or face mask, high-flow nasal oxygen therapy, noninvasive mechanical ventilation, invasive mechanical ventilation and in critical

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conditions extracorporeal membrane oxygenation procedure. The choice of technique/method depends on every individual case. If during respiratory support therapy a patient's state begins to deteriorate, a number of reasonable indications should be considered before starting invasive mechanical ventilation. The principle of providing respiratory support requires a strategic approach to prevent unwanted complications, which, in some cases, can be life-threatening.

An in-depth study and analysis of protective lung ventilation management in children receiving treatment for the severe and extremely severe course of the coronavirus disease COVID-19 complicated by lung parenchyma inflammation is quite important for gathering experience and increases chances for a favorable outcome for patients in the pediatric population.

Aim

The study aims to analyze respiratory system protection features of acute respiratory syndrome in children with a critical course of acute respiratory distress syndrome caused by the COVID-19 coronavirus infection.

Materials and methods

Chernivtsi Regional Children's Clinical Hospital, Ukraine conducted a case-control study where 37 children (the average age of the children was 10,1±0,4 years, of which 63,0% were boys and 60,0% lived in rural areas, with an average body weight of the children in the research group of 29,7±2,8 kg) had tested positive for severe acute respiratory syndrome caused by COVID-19.

Hospitalization of children to the pediatric clinic occurred on average 6,6±0,62 days after the onset of the disease and was mostly associated with systemic disorders and water-electrolyte imbalance, which required prosthetics of the respiratory function, correction of hemodynamics and water-electrolyte violations, which were carried out in the infectious department of anesthesiology and intensive care for an average of 5,2±0,7 days.

The average duration of inpatient treatment was 12,2±1,25 days. Positive results for SARS-CoV-2 were confirmed by the reaction of reverse transcription-polymerase chain reaction (RT-PCR) from nasopharyngeal swabs or exhaled breath condensate based on positive results. Thus, test results for SARS-CoV-2 came back positive for 97,3% of patients admitted to the pediatric clinic, one child was diagnosed with multisystem inflammatory syndrome.

Diagnostic testing and treatment procedures have been carried out in adherence to current national standards and guidelines (Order of the Ministry of Health of Ukraine No. 762 dd. 02.02.2020; Order of the Ministry of Health of Ukraine No. 1380 dd. 02.08.2022).

According to the chosen study design, each patient had to meet all the inclusion criteria and have no exclusion criteria.

Inclusion criteria:

– children aged 0-18 years with respiratory disorders requiring respiratory support;
– children who have been diagnosed with COVID-19 coronavirus disease based on a positive rapid Ag test for SARS-CoV-2 virus and/or PCR for SARS-CoV-2 virus RNA in nasal or oropharyngeal swabs or exhaled air condensate based on its positive results;
– informed consent of the patient, parents or legal representative to cooperate with the investigator in the study.

Non-entry criteria:

– age >18 years;
– presence of chronic upper and lower respiratory tract disease (chronic tonsillitis, cystic fibrosis, bronchiectasis, α1-antitrepsin deficiency, chronic bronchitis in patients with tracheostomy tubes);
– patients with infectious inflammation of the respiratory system of mild and moderate severity;
– inflammation of the upper and lower respiratory tract of non-infectious etiology, of any severity.

The study was conducted by the Declaration of Helsinki ethical principles. Informed consent for this medical study has been given by parents freely and voluntarily.

Results

The average duration of onset symptoms to intensive care unit admission was 6,6±0,62 due to ineffective outpatient treatment management. Therefore, most often, patients were referred by a general practitioner or family medicine physician (64,9%) or by the team of the "Chernivtsi Emer-

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gency Medical Care and Disaster Medicine Center" (13,5%).

Upon admission, children most frequently complained of fever (78,4%), general weakness (67,6%), cough (63,9%), shortness of breath (59,5%), headache (43,2%), myalgia, and arthralgia (45,9%), picture 1. During inpatient treatment 97,3% of patients pronounced general weakness, 78,4% of patients experienced decreased or loss of appetite, 35,1% had headaches, and a third of the children experienced loss or alteration of taste and/or smell (32,4% and 29,7% respectively). Most children predominantly indicated symptoms of lower respiratory tract infection such as cough (81,1% of cases), shortness of breath (51,4%), and chest pain (16,2%). Initial symptoms of upper respiratory tract infection were pharyngitis (51,4%) and rhinopharyngitis (32,4%).

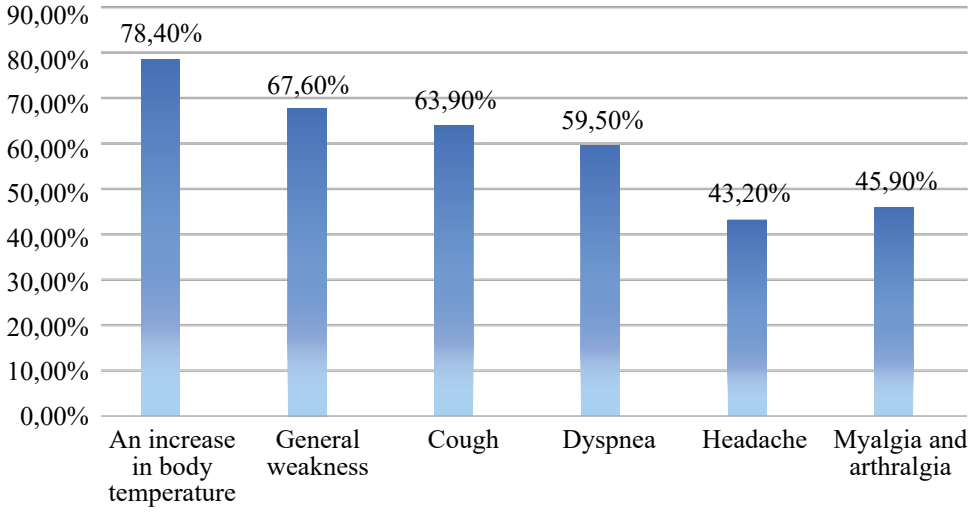
Imaging findings of the pulmonary parenchyma and interstitium confirmed unilateral lung infection (right lung pneumonia was verified in 43,3% of children and left lung pneumonia was confirmed in 21,6% of patients), while every fourth child (27,0%) suffered from bilateral pneumonia. Interstitial lung inflammation was observed in 8,1% of patients, and pneumonia complicated by exudative pleuritis was seen in 5,4% of cases. To sum up, 97,3% of cases exhibited respiratory failure (Grade II and above), where 82,2% were severe and 17,8% were critically severe.

During physical assessment, 45,9% of patients were found to have abnormal breath sounds and 91,9% of patients experienced shortness of breath. Notably, every fourth child tested negative for SARS-CoV-2 RNA on the 14,0±1,54 day of inpatient treatment while having clinical symptoms. This may likely indicate a bacterial superinfection.

The comprehensive treatment of patients with severe and extremely severe respiratory distress syndrome of coronavirus disease included respiratory and hemodynamic protection, antiviral and antibacterial therapy, the use of parenteral glucocorticosteroids and anticoagulants, which were in line with current national regulatory guidelines and local protocols. In particular, given the presence of intoxication syndrome and dehydration, all children in the study cohort received infusion therapy with glucose-salt solutions.

8,1% of patients with a critically severe course of the disease were treated with a combined immune corrective therapy along with an antiviral adenosine triphosphate nucleotide analog drugs, which inhibit RNA-dependent RNA polymerase and stops the growth of the viral RNA chain (remdesivir) and intravenous normal human immunoglobulin.

All children presented to the hospital with severe conditions. The assessment of X-ray imaging results indicated changes in lung picture suggesting possible bacterial respiratory tract infection, and general bacterial infection based on blood work results. These data suggest antiviral medication protocol which is regulated by the current national standards and guidelines (Order of the Ministry of Health of Ukraine No. 762 dd. 02.02.2020; Order of the Ministry of Health of Ukraine No. 1380 dd. 02.08.2022).



Picture 1. Leading clinical markers in children with pneumonia

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COVID patients under the age of 18 who were treated in the intensive care unit and were at risk for venous thromboembolism, according to laboratory test data (increase in D-dimer, C-reactive protein, decrease in active partial prothrombin time), were considered a target cohort for low molecular weight heparin therapy as antithrombotic prophylaxis (80,3%). Adjustment of the dose and duration of anticoagulant therapy was decided individually in each specific case based on the data of laboratory markers of thromboembolism and was on average 5,4±0,5 days.

Systemic corticosteroids were used to treat inpatients in the cohort study in adherence to the severe COVID-19 treatment protocol.

All children admitted to the intensive care unit required respiratory support due to existing respiratory disorders. The choice of respiratory support management was determined individually in each specific clinical case with a preference for gentle, non-invasive methods. Most of the patients (62,2%) with normal breathing, yet whose oxygen saturation levels (Studies on the Oxygen Saturation of Arterial Human Blood – SpO_2) were below 92%, received oxygen support through an oxygen mask or nasal cannula.

At the same time, nearly one-third of children required non-invasive and invasive mechanical ventilation as high-flow humidified oxygen therapy was not enough. 29,7% of patients were treated using continuous positive airway pressure therapy (CPAP therapy) with oxygenation index (FiO_2) 0,4-0,5 and positive end-expiratory pressure (PEEP) of 4-5 cm H_2O. 8,1% of hospitalized children were put either on pressure-assisted controlled ventilation (P-A/C) or synchronized intermittent mandatory ventilation (SIMV). It is worth noting that children receiving noninvasive continuous positive airway pressure ventilation support required a lower concentration of oxygen in the inhaled mixture compared to those on free-flow oxygen support.

Those children who have been showing worsening signs of cardiorespiratory distress syndrome while under NIV support, underwent orotracheal intubation under direct laryngoscopy with a thermoplastic polyvinyl chloride tube with a large-volume low-pressure cuff and an X-ray contrast strip mounted in the tube wall, followed by a transition to mechanical lung ventilation.

Supplemental respiratory support therapy for patients with restrictive breathing has included the use of invasive mechanical ventilation in the mode of adaptive support ventilation and synchronized intermittent mandatory ventilation (Marraro G. A., & Spada C., 2020). To support better coordination between the patients and the mechanical ventilation machine, we were switching between intermittent positive pressure-assisted controlled ventilation mode and synchronized intermittent mandatory ventilation. Once it is determined that the patient is likely to tolerate spontaneous active breathing, one can continue with extubation followed by continuous positive airway pressure (CPAP) oxygen support through a mask or nasal system (nCPAP).

When planning a lung protection support strategy for ventilated patients we set the ventilator parameters to achieve the lowest possible tidal volume (TV) for the patient's ideal body weight, the lowest possible oxygen concentration in the inhaled air, while simultaneously maintaining recommended high levels of peak inspiratory pressure (PIP/P_{insp}), positive end-expiratory pressure (PEEP), and longer inspiratory time (time inspiratory TI/T_{insp}) or peak inspiratory flow (PIF).

To maintain spontaneous active breathing capability in children, the initial ventilator mode was set to P-A/C with a flow trigger of 2,8 l/min. For further treatment strategy it was crucial to determine the ideal body weight (IBW). The lung volume is best correlated with height (m) rather than weight (kg), the IBW was calculated as ($h^2 \times 22$) where h is height in meters. The next step was to determine the optimal tidal volume. The generally recommended TV target is 4-6 ml per kg of ideal body weight, but given increased lung stiffness caused by acute respiratory distress syndrome, the TV was set at 6 ml/IBW. The next important step was to determine minute ventilation (MV), which was calculated as (IBW (kg) × 100). By entering the patient's TV and MV we were able to set the respiratory rate (RR) required to achieve arterial blood oxygen saturation target within the range of 88-95%. The RR was calculated as (RR = MV/TV).

After all the calculations, the decision has been made to set FiO_2 at 60% followed by attempts to reduce %, since a high concentration of oxygen in the inhaled oxygen-air mixture triggers proteins and lipid peroxidation, which are an integral part of

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cell membranes and biologically active substances, causing oxidative damage to the alveoli.

The next step was to set the P_{insp} and PEEP values, which create constant pressure within the ventilator breathing circuit to prevent alveolar collapse at the end of expiration and open those areas of the lungs affected by atelectasis. This promotes non-functional alveoli to open and keep it that way, thereby increasing surface area for gas exchange, lowering the risk of shunting of deoxygenated blood, and improving the ventilation-perfusion ratio and the alveolar-arterial oxygen gradient.

At the same time, the goal was to maintain the inspiratory flow as low as possible, which would help improve lung ventilation by ensuring the even distribution of the oxygen-air mixture across the entire lung surface. The initial value of inspiratory flow was set at 18-20 cmH_2O, T_{insp} at 0,5 sec, and a PEEP at 6-8 cmH_2O.

A normal inspiration (I) and expiration (E) ratio for effective gas exchange to occur in the lungs was set at 1:2-2,5. Having a prolonged and increased I:E ratio has the following effects: more time for gas exchange at the alveoli and increased mean airway pressure during the respiratory cycle. As a result, atelectatic lung areas are pneumatically open and the ventilation-perfusion ratio is improved. Mechanical ventilator parameters were set as follows (https://adst.mp.pl/s/empendium/img_zoom/B27/027_2820.jpg):

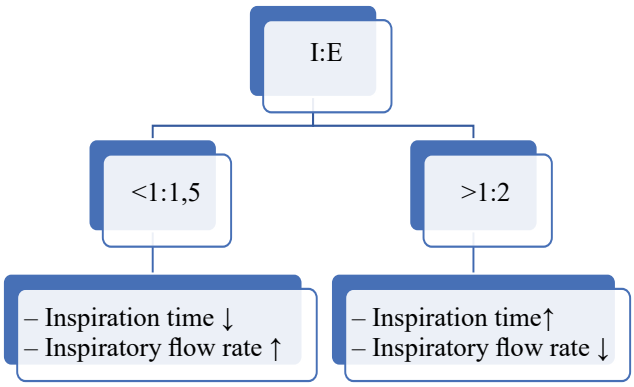

Figure. 2. How I:E ratio affects mechanical ventilator settings

More inspiratory time (I:E <1:1,5) led to an inspiratory flow rate increase and/or shortened inhalation duration, thus achieving the target range of SpO_2. Those patients failed to achieve the target SpO_2 value, and mechanical ventilator settings were set as shown in Figure 3 (https://adst.mp.pl/s/empendium/img_zoom/B27/027_2744.jpg) while adjusting the initial Pinsp value.

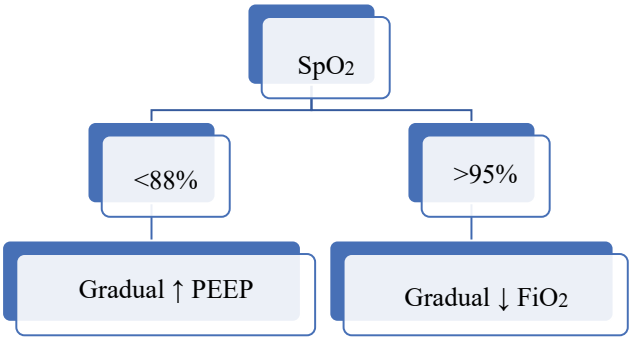

Figure. 3. SpO_2 level and ventilator settings adjustment

The initial ventilator setting was a pressure control. In order to achieve the target range of SpO_2 we adjusted the parameters of PEEP, P_{insp}, P_{peak}, respiratory rate f, T_{insp}, and FiO_2. The tidal volume (TV) delivered to the lungs with each breath varied depending on the mechanical properties of the lungs and was determined by the ventilator set parameters. Carefully monitoring SpO_2 levels with an oximeter (every 15-20 mins), we have been gradually adjusting PEEP by 2 cm H_2O. However, we had to be very cautious in maintaining the maximum allowable PEEP value (14 cm H_2O, and in rare cases 20 cm H_2O), as increasing PEEP value can cause hemodynamic disorder, decreased venous return to the heart, decreased left ventricular function, lung parenchyma overdistension, which poses a significant risk of developing barotrauma and volutrauma.

While increasing PEEP, we were gradually increasing P_{insp} to a safe value of 35 cm H_2O, as well as T_{insp} and f. Failed to reach the target range of SpO_2 value despite reaching the maximum allowable upper limits of PEEP, P_{insp}, T_{insp}, and f, the next step was to gradually increase the O_2 concentration in the inhaled mixture by 10%. SpO_2 level was monitored with an oximeter every 15-20 minutes until the intended result was achieved.

All children's arterial blood was assessed for gas and acid-base composition, combined with the results of continuous capnography and SpO_2 level monitoring to objectively adjust the mechanical ventilation parameters according to Table 1.

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Table 1. Principles of correction of ventilator parameters depending on the results of blood gas analysis (Annex 3 to the Order of the Ministry of Health of Ukraine No. 873 of 05.05.2021)

Partial Pressure of oxygen (PaO_2)	Partial Pressure of Carbon Dioxide ($PaCO_2$)	Actions
↓ PaO_2	↑ $PaCO_2$	• ↑ Peak inspiratory pressure(PIP), increases mean airway pressure; • Children that breath on their own, maybe ↑ ventilation frequency.
↓ PaO_2	N* $PaCO_2$	• ↑ Mean airway pressure; • ↑ FiO_2; • do not change PIP settings (↑ Positive end-expiratory pressure (PEEP) and/or inspiratory time Tinsp.
↓ PaO_2	↓ $PaCO_2$	• ↑ FiO_2; • ↑ Mean airway pressure (↑ PEEP and/or Tinsp); • Alternative diagnosis: persistent pulmonary hypertension, sepsis, shock.
N PaO_2	↑ $PaCO_2$	• ↓ PEEP; • ↑ ventilation frequency; • do not change Mean airway pressure
N PaO_2	↓ $PaCO_2$	• ↓ ventilation frequency; • Mean airway pressure initial settings.
↑ PaO_2	↑ $PaCO_2$	• Exclude mechanical causes of endotracheal tube obstruction; • ↓ PEEP; • ↓ T_{insp}; • ↓ FiO_2; • ↑ ventilation frequency.
↑ PaO_2	N $PaCO_2$	• ↓ mean airway preassure; • ↓ FiO_2.
↑ PaO_2	↓ $PaCO_2$	• ↓ PIP; • ↓ ventilation frequency; • ↓ FiO_2.
N PaO_2	N $PaCO_2$	• Ventilator settings remain unchanged.

Note * - N - normal (acceptable) value

Thus, in 29,7% of cases, respiratory acidosis was recorded according to the results of the gas and acid-base composition of arterial blood. In particular, in the study cohort of patients, arterial blood pH on average corresponded to 7,18±0,2, $PaCO_2$ 39,7±0,7 mmHg (95% CI 38,9-40,3), PaO_2 44,1±0,3 mmHg (95% CI 41,2-46,3), HCO_3 23,4±0,4 mmol/l (95% CI 22,8-24,1) with an average oxygenation index of 132,2±9,4 mm Hg (95% CI 126,7-135,2).

Heat-and-moisture exchangers were proven to be effective for ventilator dependent. The oxygen-air mixture was supplied to the patient via a breathing circuit at 31-37°C. The breathing circuit with the connector was complemented by a bactericidal filter, which was replaced every 96 hours.

Patients required general sedation for patient ventilator synchronization. 20% sodium oxybate drug was chosen for its nootropic properties. This sedative is a medication that has hypnotic, narcotic, central muscle-relaxing properties, enhances the analgesic activity of both narcotic and non-narcotic analgesics, increases the body's resistance to hypoxia, protects the brain, heart, retina, and activates oxidative processes.

To start a ventilator weaning process, children had to meet several criteria such as regained consciousness, improvement of acute metabolic and respiratory disorders, hemodynamic stability, decreasing secretion burden, the presence of a strong cough, and spontaneous, unassisted breathing. Once all important factors are considered, children are ready for a scheduled extubation followed by a 2-day respiratory support using a T-piece oxygen delivery system, where CPAP therapy was administered by face mask with FiO_2 at 0,3 and PEEP at

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6-8 cm H_2O. After completing nCPAP with FiO_2 of 0,3 and PEEP of 4 cm H_2O, humidified oxygen was administered via a face mask or nasal cannula until the patient regained full breathing abilities. It is worth noting that none of the critically ill respiratory distress syndrome patients required extracorporeal membrane oxygenation (ECMO).

Discussion

The article presents a clinical case study of severe acute respiratory distress syndrome caused by the SARS-CoV-2 virus in children. The severity of the child's condition is primarily caused by lower respiratory tract infection, including cough (81,1%), shortness of breath (51,4%), chest pain (16,2%), etc. Worsening of existing respiratory conditions required a directed treatment plan of prolonged respiratory system protection that was apparent to each individual.

The results of the study also confirm the data from the literature (Marraro G. A., & Spada C., 2020), which indicate that the use of a pulmonary protective strategy in the treatment of acute respiratory distress syndrome caused by an infectious and inflammatory process in the pulmonary parenchyma during the course of coronavirus disease COVID-19 is the most optimal, as it prevents the formation of atelectasis, oxidative stress, pneumofibrosis and accelerates the recovery time of patients.

This article observes cases of COVID-19 in children that, in our opinion, can be considered as confirmation that children can be affected by a severe course of coronavirus as much as adults. The treatment plan was characterized by a combination of early, aggressive, complex, and multi-target therapy to stabilize the patient's condition as quickly as possible and reduce recovery time.

Conclusions

1. The primary reason for COVID-19-associated hospitalizations to the intensive care unit is respiratory disorders caused by pneumonia.

2. A combined multi-target COVID-19 treatment plan included respiratory and hemodynamic system support, the use of systemic corticosteroids and antithrombotic drugs as well as directed antiviral and/or antibacterial therapy for superinfection

3. Noninvasive continuous positive airway pressure ventilation or high-flow oxygen therapy was considered as a primary oxygenation support treatment management plan.

4. The use of a pulmonary protective strategy in the treatment of acute respiratory distress syndrome caused by coronavirus disease COVID-19 in children requiring invasive lung ventilation was accompanied by a pronounced positive result, as it was not accompanied by side effects and resulted in a rapid recovery of patients.

5. Unlike children, in adults, the approach to respiratory function prosthetics in case of respiratory failure of the third degree requires a slightly different approach, which is associated with the anatomical and physiological characteristics of the body, the presence of concomitant pathology, metabolic processes, etc.

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Conflict of interest

The author declares no conflict of interest.

Consent to publish

This is to state that I give my full permission for the publication.

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of article.

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Менеджмент протекторної вентиляції легень у дітей із критичним перебігом гострого респіраторного дистрес-синдрому викликаним коронавірусною інфекцією SARS-CoV-2

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Анотація: *пандемія коронавірусної хвороби COVID-19 створила серйозну загрозу системі громадського здоров'я в усьому світі. З початком пандемії коронавірусної хвороби стало очевидно, що діти, інфіковані гострою респіраторною вірусною інфекцією, викликаною SARS-CoV-2, за достеменно невідомих причин, мають легший перебіг в порівнянні із дорослими, а в частині випадків, діти є безсимптомними носіями інфекції. В світлі сьогоденних наукових відкриттів, на відміну від початкових повідомлень, останні дослідження показали, що діти з такою ж ймовірністю, як і дорослі, можуть заражатися вірусом, водночас саме захворювання частіше характеризується невиразною симптоматикою та легшим перебігом. Проте, варто відмітити, що справжня поширеність безсимптомної інфекції SARS-CoV-2, швидше за все, недооцінена, оскільки тестування*

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дітей на COVID-19 без виразної клінічної симптоматики проводять в рідкісних випадках. На користь підтвердження цього факту виступають ретроспективно отримані високі титри IgG до SARS-CoV-2. В порівнянні із дорослими типовими клінічними проявами COVID-19 у дітей є гарячка, нежить, кашель та загальна слабкість. Дані лабораторних результатів дослідження характеризуються здебільшого нормальним рівнем лейкоцитів, лімфопенією, підвищенням рівня аспартатамінотрансферази, аланінамінотрансферази, D-димеру та рівня креатинкінази МВ.

Оскільки наявна етіотропна терапія захворювання наразі лише набуває доказових характеристик, комплекс терапевтичних заходів стосовно хворих на гостру респіраторну хворобу, викликану SARS-CoV-2, направлений на запобігання розвитку можливих ускладнень, а саме: респіраторна протекція, корекція гідробалансу та електролітного гомеостазу, використання протизапальних препаратів з антицитокіновою активністю, запобігання тромботичним ускладненням, лікування бактеріальної суперінфекції. Тому, аналіз особливості респіраторної протекції гострого респіраторного синдрому у дітей із критичним перебігом гострого респіраторного дистрес-синдрому викликаного коронавірусною інфекцією COVID-19, є доволі актуальним в аспекті накопичення нового досвіду з метою впровадження його в практичну діяльність закладів охорони здоров'я. Ушпиталення дітей до відділення інтенсивної терапії відбувалося в середньому на 6,6±0,62 день захворювання та в більшій мірі було пов'язано із системними розладами та порушенням водно-електролітного балансу, що потребували протезування респіраторної функції, корекції гемодинаміки та водно-електролітних порушень, що здійснювалося в умовах інфекційне відділення анестезіології та інтенсивної терапії в середньому 5,2±0,7 дня. У дітей клінічної групи верифікація SARS-CoV-2 проводилася шляхом полімеразної ланцюгової реакції зворотної транскрипції мазка з носоглотки та/або конденсату видихуваного повітря на підставі її позитивних результатів. Комплексне лікування хворих з тяжким та вкрай тяжким респіраторним дистрес-синдромом при коронавірусній хворобі включало заходи респіраторної, гемодинамічної протекції, противірусну та антибактеріальну терапію, використання парентеральних глюкокортикостероїдів та антикоагулянтів, що відповідало чинним національним регламентувальним настановам та локальним протоколам. Відповідно до критеріїв вибору методу протезування респіраторної функції у більшої половини пацієнтів (62,2%), в яких рівень насичення гемоглобіну киснем становив менше, ніж 92%, при збережені активної дихальної спроможності, респіраторна підтримка проводилася шляхом дотації зволоженого кисню через лицеву маску або назальні канюлі. Ще у 29,7% пацієнтів проводилася неінвазивна вентиляція шляхом постійного позитивного тиску в дихальних шляхах, при індексі оксигенації 0,4-0,5 та позитивному тиску в кінці видиху 4-5 см водного стовпчика. Діти, які мали критичний перебіг гострого респіраторного синдрому викликаного коронавірусною інфекцією COVID-19 (8,1%) та в яких неінвазивні методи респіраторної підтримки не приносили бажаного терапевтичного результату перебували на інвазивній вентиляції легень в режимі допоміжної контрольованої вентиляції або в режимі синхронізованої переміжної примусової вентиляції. Слід відмітити, що діти, яким респіраторна підтримка проводилася у вигляді неінвазивної вентиляції шляхом постійного позитивного тиску в дихальних шляхах, потребували меншої концентрації кисню у вдихувальній суміші у порівнянні з хворими, що перебували на кисневій дотації вільним потоком. Необхідність ушпиталення у відділення інтенсивної терапії дітей, хворих на COVID-19, в першу чергу пов'язано з респіраторними розладами, зумовленими інтерстиційною пневмонією. Проведення кисневої дотації мало першочергове значення у менеджментів пацієнтів пріоритетно шляхом неінвазивної вентиляції легень з постійним позитивним тиском в дихальних шляхах або вільним потоком. Застосування легенево-протективної стратегії в лікуванні гострого респіраторного дистрес-синдрому зумовленого коронавірусною хворобою COVID-19 у дітей які потребували інвазивної вентиляції легень супроводжувалося вираженим позитивним результатом, так як не супроводжувалося побічними наслідками та закінчувалося швидким одужанням пацієнтів.

Ключові слова: діти, респіраторний дистрес, пневмонія, COVID-19, відділення інтенсивної терапії, респіраторна підтримка.