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COVID-19 – what should anaesthesiologists and intensivists know about it?

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Abstract

Over the past three months, the world has faced an unprecedented health hazard. The World Health Organization has announced a pandemia infection with an unknown species of coronavirus called SARS-CoV-2. Spreading mainly through the droplet route, the virus causes mild symptoms in the majority of cases, the most common being: fever (80%), dry cough (56%), fatigue (22%) and muscle pain (7%); less common symptoms include a sore throat, a runny nose, diarrhea, hemoptysis and chills. A life-threatening complication of SARS-CoV-2 infection is an acute respiratory distress syndrome (ARDS), which occurs more often in older adults, those with immune disorders and co-morbidities. Severe forms of the infection, being an indication for treatment in the intensive care unit, comprise acute lung inflammation, ARDS, sepsis and septic shock. The article presents basic information about etiology, pathogenesis and diagnostics (with particular emphasis on the importance of tomocomputer imaging), clinical picture, treatment and prevention of the infection. It goes on to emphasize the specific risks of providing anesthesiology and intensive care services. Due to the fact that effective causal treatment is not yet available and the number of infections and deaths increases day by day, infection prevention and strict adherence to recommendations of infection control organizations remain the basis for fighting the virus.

Key words: viruses, SARS-CoV-2, infection, COVID-19, acute pneumonia, acute respiratory distress syndrome (ARDS).

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In the last months of 2019, disturbing news from China began to spread around the world about the increased incidence of viral infections, which turned out to be caused by a coronavirus. It was originally referred to as 2019-nCov, now as SARS-CoV-2; the disease it caused has been named COVID-19 by the World Health Organization (WHO) (11 February 2020).

At present it is known that the virus has reached Europe (including Poland) and the highest number of cases has been recorded in the northern part of Italy. The knowledge regarding epidemiology is changing dynamically, so is the scope of information about the virus. This paper aims to provide up-to-date information on COVID-19, which should be important for anaesthetists, intensivists and trainees in this specialty. We are aware that new findings are reported every day; therefore, it is essential to keep track of online sources of information, including websites of the Ministry of Health and the Chief Sanitary Inspector. The most important guidelines and updates on COVID-19 are being translated into Polish and published online: https://konsultantait.gumed.edu.pl/.

AETIOLOGY AND PATHOGENESIS

According to the data published by the WHO, the first cases of unknown aetiology appeared in the city of Wuhan, the Chinese province of Hubei in early December 2019. Infections with influenza virus, avian influenza virus, adenovirus, severe acute respiratory syndrome coronavirus (SARS-CoV), and Middle East respiratory syndrome coronavirus (MERS-CoV) were all excluded; subsequently, the previously unknown type of coronavirus was isolated on 07.01.2020, which was originally called the "novel coronavirus" (nCoV) [1]. Currently, the pathogen is named SARS-CoV-2.

SARS-CoV-2 is a positive-sense single-stranded RNA virus, it has a spherical shape, and the spike (S) protein located on the surface of its envelope, forming pronounced projections, which in electron micrographs create an image reminiscent of solar

corona. Taxonomically identified last year, the virus belongs to the order *Nidovirales*, family *Coronaviridae*, subfamily (group) *Orthocoronavirinae* [2].

Depending on the serotype and genotype, coronaviruses are divided into four types identified as α, β, γ, δ [3]. SARS-CoV-2 is a new, seventh coronavirus belonging to the β-coronavirus subtype that causes infections in humans [4].

The trophism and pathogenicity of the virus determine its classification to a respective group; α coronaviruses most often cause mild upper respiratory tract infections, β viruses are highly pathogenic and can cause pneumonia and severe respiratory disorders (severe acute respiratory syndrome – SARS, Middle East respiratory syndrome – MERS). β coronaviruses have caused two prior outbreaks of massive respiratory infections in humans – at the turn of 2002 and 2003 in China (SARS) and in 2013 in Saudi Arabia (MERS) [5–7].

The virus identified last year in China resembles the viruses causing SARS (in 45–90%) and MERS (in 20–60%). It also causes SARS-like respiratory tract infections, hence its name: SARS-CoV-2. However, it shows the greatest genetic similarity (96%) to the genome of coronaviruses found in bats, which probably were its first host. To date, it is uncertain how transmission to humans has occurred and whether other animal species have participated in this process [8, 9].

Most probably, the S protein located on the surface of the virus reacts with the molecules of the angiotensin-converting enzyme 2 (ACE 2) in the lungs [4]. The angiotensin-converting enzyme 2 occurs in the alveolar epithelial cells (pneumocytes), mainly type II. Its concentration is higher in men, which may explain a higher incidence rate among men as compared women. Binding of ACE to SARS-CoV-2, as with SARS-CoV, may lead to its increased expression, resulting in damage to the alveoli. The affinity of SARS-CoV-2 for ACE is 1 to 2 times higher than that of SARS-CoV. The expression of ACE varies in individuals of different races, hence the differences in susceptibility to disease and in severity of its course [10, 11]. Interactions of the virus with angiotensin-converting enzyme 2 may form the basis for research into potential therapeutic options [12–14].

After infection, viral replication occurs in the cells of the respiratory and intestinal epithelium, which leads to cytopathic changes and clinical symptoms.

EPIDEMIOLOGY

Coronaviruses have been a common pathogen for upper respiratory tract infections for years, both in adults and children. They are responsible for about 20% of such infections. Infections usually last for several days and have a mild course [15]. With the discovery of the new virus, research into its epidemiology began. A link was found between morbidity and working on the seafood and exotic animal market in Wuhan [16, 17]. Subsequent patients had no contact with the above-mentioned place, and the disease covered almost the entire world. According to the data from the European Centre for Disease Prevention and Control, 102 132 cases of disease were diagnosed between 31.12.2020 and 07.03.2020, of which 3488 were fatal, which means a mortality rate of 3.4% [18].

As the epidemic in China preceded the worldwide spread of the virus, most data on the epidemiology and clinical course of COVID-19 comes from that country. The ease with which the virus spreads has been indicated by Wang *et al*., who reported that that between 01.12.2019 and 26.01.2020, 1975 individuals were infected and 56 died, which translates into a mortality of 2.84%. Another 2,684 people were suspected of being infected. The time from infection to death was shorter for patients older than 70 years as compared to younger patients (the median times were 11.5 and 20 days, respectively). Furthermore, Huang *et al*. [16] have demonstrated the mortality rate of 15%. The median age was 49 years, and 32% of patients had comorbidities; 32% of patients required admission to an intensive care unit (ICU), because they needed high-flow nasal oxygen therapy or supply of higher concentrations of oxygen. The authors have not provided any data on whether mechanical lung ventilation was necessary.

The virus spreads via droplets and through direct contact with an infected person. Cases of spreading the virus by air have not been confirmed and, although not considered significant, it cannot be ignored when medical procedures related to the formation of aerosol are carried out [20]. The virus is also found in the blood and faeces of the infected [21]. In 2003, data was published suggesting that the SARS virus also spreads if an aerosol forms into which the faecal content of an infected patient enters [22]. Clearly determining whether this route is significant for SARS-CoV-2 requires further research [21]. The conjunctiva of the eye is very likely to be the portal of entry for the infection due to easy contamination with fluids.

The incubation period of the virus is on average 6.4 days (from 2.1 to 11.1 days); however, taking into account the distribution of the incubation period, the authors of the quoted report are of the opinion that in order to ensure a safe duration of quarantine, it is reasonable to assume the incubation time between 2.4 and 15.5 days [23]. On the other hand, according to the WHO data, the time to onset of symptoms is between 1 and 14 days, usually 5 days [24].

Epidemiological data of patients treated in ICUs are limited. Individual countries differ in the cri-

teria for ICU admission; hence the comparison of data may be unreliable. According to a retrospective, single-centre study covering the period from 01.01.2020 to 20.01.2020, out of 99 infected individuals in China, three in four patients required oxygen therapy – 13% were treated with non-invasive ventilation, 4% with invasive ventilation. In 9% of cases continuous renal replacement therapy was used, and in 3% – extracorporeal membrane oxygenation. The condition of 11% of patients (11 patients) significantly deteriorated within a short time and these patients died due to multiple organ failure [25].

In Paris, by 04.02.2020, four infected patients were admitted to the reference hospital, two of whom were transferred to the ICU. The authors have provided further data (not covering the entire period of treatment at the ICU) on one patient who was treated with oxygen goggles from the 7th day of hospitalisation; on the 8th day, due to the development of ARDS, the patient was admitted to the ICU and mechanical ventilation was implemented. In the next three days, the patient still required respiratory therapy [26]. At the time of writing the article, a critical situation was observed in Italy: by 23:50 Central European Time of 07.03.2020, 5883 cases were reported. Germany and France came second and third in Europe, with 795 and 716 confirmed cases of infection, respectively. In Poland, there were 5 infected patients at the time. The above data come from the WHO website: https://who.maps.arcgis.com/apps/opsdashboard/index.html#/ead3c6475654481ca51c248d52ab9c61, and are successively updated.

DIAGNOSTICS

The first step in diagnosing SARS-CoV-2 infection is a positive epidemiological history. The risk factors for infection are divided into two groups – A and B. The infection should be suspected if any of the group A factors and 2 group B symptoms, or three and more group B symptoms have occurred [4].

Group A factors (epidemiological) – within two weeks before symptoms onset:

- history of travel or residence in the district with a confirmed case or living in this area,
- contact with a patient with COVID-19 confirmed with PCR,
- contact with a person from an area where the infection occurs that presents with fever and signs of infection,
- confirmed cases within the immediate surroundings (family, coworkers, neighbours).

Group B factors (clinical symptoms) encompass:

- fever and/or other respiratory symptoms,
- radiologically confirmed pneumonia with characteristic radiological features,
- in the early stage of the disease – normal/decreased leucocyte count or lymphopenia.

Laboratory tests

Leukopenia and lymphopenia, which are characteristic of SARS-CoV-2 infection, occur at the initial stage of the disease. However, 25–30% of patients presented with leucocytosis [27]. Infected individuals also have had increased activity of transaminases (ALT and AST), creatine phosphokinase (CPK) and lactate dehydrogenase (LDH), increased myoglobin, and sometimes troponin. In most patients, C-reactive protein (CRP) levels are increased, while procalcitonin levels remain normal. Increased D-dimer and creatinine levels, leucocytosis with agranulocytosis, and increased lactate levels are observed in severe infections.

High levels of cytokines (IL-2, IL-7, IL-10, GSCF, IP10, MCP1, MIP1a and TNF-α) were found in patients developing severe infections and treated in intensive care units, but not in patients with mild infection [16].

Radiological features

Radiological imaging by means of a CT chest scan is important for the diagnosis of the infection – radiologically confirmed pneumonia with characteristic lesions is one of the group B symptoms. The detected changes are characteristic of severe respiratory infections and are bilateral, as in SARS.

In the early phase, the most prevalent radiological features are patchy ground-glass opacities and interstitial changes. As the disease progresses, the opacities become more regular (round) and infiltrative lesions appear. In the most severe cases, consolidation changes occur, without pleural effusion, which is a very characteristic picture [16, 28].

Based on the CT scan of the lungs, five stages of infection have been identified.

1. Ultra-early stage, still without clinical manifestations or laboratory deviations. The chest examination reveals single or diffuse foci of clouding, enlarged lymph nodes in the middle sections of the lungs, often surrounded by circular opacities; consolidations may occur. Air bronchogram becomes visible.
2. Early stage, observed within 1–3 days of the onset of symptoms. As a result of dilatation and hyperaemia of the alveolar-capillary membrane, an exudate into the lumen of the alveoli and a picture of interstitial oedema are observed.
3. The third stage is characterized by rapid progression of changes. In the period of 3–7 days from the onset of symptoms, the changes described in the second stage intensify, which results in increased alveolar and interstitial oedema, more-

over, merging consolidations with air bronchogram are visible.
4. The fourth stage is the stage of consolidation lesions – they occur as a result of fibrin deposition in the lumen of the alveoli and in the interstitium.
5. In the fifth stage consolidation, the changes evolve – interlobular septal thickening and striped densities, spreading along the bronchi are visible.

The importance of CT exams is evidenced by the fact that changes in the lung tomographic image in individuals with confirmed SARS-CoV-2 infection are seen in 80–100% of cases [16].

According to the Radiological Society of North America, since the number of molecular tests to confirm SARS-CoV-2 infection is insufficient, computed tomography imaging has become essential for diagnosing patients with suspected infection [29].

Preliminary reports form China suggest great applicability of lung ultrasonography in diagnostics of COVID-19. Polish translation of the available descriptions of characteristic USG features are available at: https://konsultantait.gumed.edu.pl/.

Confirmation of infection

In patients with a positive epidemiological history and clinical symptoms, SARS-CoV-2 infection should be confirmed by a reliable diagnostic test.

In the initial period of infection, respiratory tract specimens should be collected as the number of viral copies is highest in the airways and a positive test result is obtained, whereas blood testing may give a false negative result. The biological material is sampled from the lower respiratory tract (transtracheal aspirates [TTA] or bronchoalveolar lavage [BAL]), uninduced sputum, swabs, and nasopharyngeal aspirates.

Molecular tests, such as RT-PCR (reverse transcription polymerase chain reaction), RT-LAMP (reverse transcription LOOP-mediated isothermal amplification), RT-iiPCR (reverse transcription insulated isothermal polymerase chain reaction), r-RT-PCR (real-time reverse transcription-polymerase chain reaction) are based on detecting the genetic material of the virus in a particular sample. There are currently 7 potentially diagnostic tests available to confirm SARS-CoV-2 infection; unfortunately, most of them are difficult to access and are used mainly for scientific purposes. Moreover, two tests were developed to detect SARS-CoV-2 among other pathogens (respiratory multipanel) [4, 30].

In Poland, the State Sanitary Inspection and the National Institute of Hygiene are currently responsible for the laboratory diagnostics – samples with biological material should be sent to these laboratories, using the appropriate instructions.

CLINICAL SIGNS AND COURSE OF INFECTION IN THE MOST SEVERELY ILL PATIENTS

It is known that the vast majority of individuals infected with SARS-CoV-2 have a mild infection and the symptoms are not specific. The most common symptoms of infection are fever (80%), dry cough (56%), fatigue (22%), muscle pain (7%); the less common symptoms include sore throat, runny nose, diarrhoea, haemoptysis, chills [25]. About a week after infection, the patient may rapidly deteriorate with increased respiratory failure symptoms [4]. ARDS is a complication of SARS-CoV-2 virus infection which is more common in older people, those with impaired immunity and comorbidities, including hypertension, diabetes, coronary artery disease, bronchitis, ischaemic changes of the central nervous system, and Parkinson's disease.

Severe forms that are indications for ICU treatment are acute pneumonia, ARDS, sepsis and septic shock. Their characteristics are presented in Table 1.

In February 2020, the "New England Journal of Medicine" presented the clinical characteristics of infections in China (552 hospitals in 30 provinces) – 5% of patients required ICU hospitalization. The median age was 63 years (IQR 53.3–71.0). The median incubation time was 4 days (IQR 1.0–7.5 days). In the group of patients requiring ICU treatment, as compared to those who did not require such treatment, significantly higher rates of concomitant chronic diseases were noted, including hypertension (35.8% vs. 13.5%), diabetes (26.9% vs. 6.1%), or COPD (10.4% vs. 0.5%). The median incubation time was 4 days (1st and 3rd quartiles – 2 and 7 days, respectively). ARDS was diagnosed in 40% of patients treated in ICUs, acute kidney damage (AKI) in 6% and septic shock in 13.4% of patients. Mechanical ventilation was used in almost 60% of patients. 22.4% of those treated in ITUs died, while in the general population the death rate was 1.4% [31]. In the study summarizing the experience of one intensive care centre in Wuhan, a definite majority of male patients (67%) was found, while the median number of days from the onset of symptoms to ICU admission was 9.5 days (IQR 7–12.5 days). ARDS was diagnosed in 67% of patients, AKI in 29%, and liver dysfunction in the same percentage of patients (29%) [32].

TREATMENT

Patients with COVID-19 should be treated in designated centres. A significant proportion of patients with pneumonia requires passive oxygen therapy. It should be used in patients with shortness of breath, hypoxaemia or those in shock. Oxygen treatment should be started with a flow of 5 L min^{-1}, and then the flow should be gradually titrated to maintain

TABLE 1. Clinical syndromes associated with COVID-19 [Source: https://www.who.int/publications-detail/clinical-management-ofsevere-acute-respiratory-infection-when-novel-coronavirus-(ncov)-infection-is-suspected]

Severe pneumonia	**Adolescent or adult:** fever or suspected respiratory infection, plus one of the following: – respiratory rate > 30 breaths/min; – severe respiratory distress; or $SpO_2 \leq 93\%$ on room air. **Child** with cough or difficulty in breathing, plus at least one of the following: – central cyanosis or $SpO_2 < 90\%$; – severe respiratory distress (e.g. grunting, very severe chest indrawing); – signs of pneumonia with a general danger sign: inability to breastfeed or drink, lethargy or unconsciousness, or convulsions. Other signs of pneumonia may be present: chest indrawing, fast breathing (in breaths/min): < 2 months: ≥ 60; 2–11 months: ≥ 50; 1–5 years: ≥ 40. While the diagnosis is made on clinical grounds; chest imaging may identify or exclude some pulmonary complications.
Acute respiratory distress syndrome (ARDS)	**Onset:** within 1 week of a known clinical insult or new or worsening respiratory symptoms. **Chest imaging (radiograph, CT scan, or lung ultrasound):** bilateral opacities, not fully explained by volume overload, lobar or lung collapse, or nodules. **Origin of pulmonary infiltrates:** respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (e.g. echocardiography) to exclude hydrostatic cause of infiltrates/oedema if no risk factor present. **Oxygenation impairment in adults:** – mild ARDS: 200 mm Hg < $PaO_2/FiO_2 \leq 300$ mm Hg (with PEEP or CPAP ≥ 5 cmH_2O, or non-ventilated); – moderate ARDS: 100 mm Hg < $PaO_2/FiO_2 \leq 200$ mm Hg (with PEEP ≥ 5 cmH_2O, or non-ventilated); – severe ARDS: $PaO_2/FiO_2 \leq 100$ mm Hg (with PEEP ≥ 5 cmH_2O, or non-ventilated). When PaO_2 is not available, $SpO2/FiO_2 \leq 315$ suggests ARDS (including in non-ventilated patients). **Oxygenation impairment in children:** (**N**ote: OI = Oxygenation Index, and OSI = Oxygenation Index using SpO_2. Use PaO_2-based metric when available. If PaO_2 not available, wean FiO_2 to maintain $SpO_2 \leq 97\%$ to calculate OSI or SpO_2/FiO_2 ratio.) – Bilevel (NIV or CPAP) ≥ 5 cmH_2O via full face mask: $PaO_2/FiO_2 \leq 300$ mm Hg or $SpO_2/FiO_2 \leq 264$; – Mild ARDS (invasively ventilated): 4 ≤ OI < 8 or 5 ≤ OSI < 7.5; – Moderate ARDS (invasively ventilated): 8 ≤ OI < 16 or 7.5 ≤ OSI < 12.3; – Severe ARDS (invasively ventilated): OI ≥ 16 or OSI ≥ 12.3.
Sepsis	**Adults:** life-threatening organ dysfunction caused by a dysregulated host response to suspected or proven infection. Signs of organ dysfunction include: altered mental status, difficult or fast breathing, low oxygen saturation, reduced urine output, fast heart rate, weak pulse, cold extremities or low blood pressure, skin mottling, or laboratory evidence of coagulopathy, thrombocytopenia, acidosis, high lactate, or hyperbilirubinemia. **Children:** suspected or proven infection and ≥ 2 age- based systemic inflammatory response syndrome criteria, of which one must be abnormal temperature or white blood cell count.
Septic shock	**Adults:** persisting hypotension despite volume resuscitation, requiring vasopressors to maintain MAP MAP ≥ 65 mm Hg and serum lactate level > 2 mmoL L^{-1}. **Children:** any hypotension (SBP < 5th centile or > 2 SD below normal for age) or two or three of the following: altered mental state; tachycardia or bradycardia (HR < 90 bpm or > 160 bpm in infants and HR < 70 bpm or > 150 bpm in children); prolonged capillary refill (> 2 s) or feeble pulse; tachypnoea; mottled or cool skin or petechial or purpuric rash; increased lactate; oliguria; hyperthermia or hypothermia.

SpO_2 at an appropriate level (adult $SpO_2 \geq 90\%$, pregnant SpO_2 92–95%, children's $SpO_2 \geq 90\%$, and in children with additional concomitant airway obstruction, apnoea, respiratory failure, central cyanosis, those in shock, coma or with convulsions $SpO_2 \geq 94\%$).

Mechanical ventilation is necessary in patients with hypoxic respiratory failure and ARDS. Attempts have been made to use non-invasive mechanical ventilation (NIV) and high flow nasal oxygen therapy (HFNO). However, these methods do not work in patients with severe hypercapnia, hemodynamically unstable, with multi-organ failure and impaired consciousness. The WHO guidelines suggest that these methods may be helpful in people with mild to moderate non-progressive hypercapnia, but such patients should be very carefully monitored for worsening respiratory function. In the absence of improvement within 1 hour of using HFNO, tracheal intubation and mechanical ventilation of the lungs should be initiated [30]. In addition, they are aerosol-generating respiratory support methods that may increase the risk of virus transmission [33].

A lung-protective ventilation strategy should be applied – tidal volumes should not exceed 4–6 mL kg^{-1} predicted body weight (PBW), and respiration rates should be as low as possible – allowing to maintain a pH greater than 7.2. A tidal volume of up to 8 mL kg^{-1} of PBW is acceptable if adverse events occur (e.g. dyssynchrony, pH < 7.15). It is recommended to use high or very high positive end-expiratory pressure (PEEP), determined by means of titration, so as to obtain satisfactory saturation with the lowest feasible FiO_2, without generating

too much pulmonary vascular resistance at the end of inspiration. In practice, the PEEP values range between 13 and 24 cm H_2O. In patients with severe COVID-19-related ARDS, the lung compliance is usually high, so inspiratory pressures rarely exceed 13 cm H_2O, and plateau pressures are not higher than 25–27 cm H_2O (unpublished information from Prof. Paolo Pelosi).

The use of ventilation in the prone position provides good results in patients unresponsive to conventional methods of respiratory therapy. However, the time the medical team needs to put on protective clothing should be considered. It is recommended to keep the patient in the prone position over 12 hours a day, provided that his/her clinical condition allows it. Avoid disconnecting the ventilator system.

The WHO guidelines refer relatively positively to the use of extracorporeal membrane oxygenation (ECMO), while simultaneously indicating that its use is limited to expert centres with appropriate experience and technical capabilities. Other experts are more cautious about recommending the use of ECMO in COVID-19 [34] is emphasized that this method is not applicable in the case of a significant number of cases, and there is currently no clear evidence of the usefulness of ECMO in the discussed disease.

Specific pharmacological treatment for the new 2019-nCoV coronavirus is not available. Some centres are using empirical antiviral therapy with darunavir or lopinavir in combination with ritonavir and oseltamivir and hydroxychloroquine [30, 35]. Moreover, no data have been reported regarding the use of aerosolised interferon-α interferon. Unfortunately, there are no available randomized clinical trials that would confirm the efficacy of any specific pharmacological treatment option.

Preventive administration of antibiotics should not take place without microbiologically confirmed bacterial superinfection. In confirmed bacterial infections, broad-spectrum empirical antibiotic therapy should be avoided; rather targeted antibiotic therapy should be used with de-escalation of treatment as early as possible. In patients with circulatory insufficiency, the use of noradrenaline is recommended to maintain organ perfusion at the expense of possibly restrictive fluid therapy. Glucocorticosteroids should not be given to patients routinely. Only in septic shock resistant to vasopressor therapy, 50 mg intravenous hydrocortisone every 6 hours is recommended. The neuromuscular block should be limited exclusively to cases of significant patient-ventilator dyssynchrony preventing the achievement of the set tidal volumes, or to cases of rapidly progressing hypoxaemia or hypercapnia.

PRECAUTIONS AND PREVENTION OF INFECTIONS AMONG THE ICU STAFF

A cardinal problem associated with the treatment of people diagnosed/suspected of COVID-19 is the introduction of appropriate precautions against transmission of infection to members of the ICU staff.

The proper use of personal protective equipment (PPE), described in detail in the guidelines of the European Center for Disease Prevention and Control, is of utmost importance. The guidelines also contain information on the use of substitutes. Polish translation can be found at: https://konsultantait.gumed.edu.pl/.

Although putting on PPE properly is extremely important, it should be remembered that the risk of transmission increases significantly when one removes it.

It is necessary to carry out training for all personnel who will be using PPE, remembering that the equipment used for the practice should be secured and used again while working with the patients, as sterile clothing is not required.

Anesthesia procedures that carry a high risk of infection include those during which aerosol is formed, which may penetrate the respiratory tract or the conjunctival sac of the medical personnel. These are tracheal intubation, replacement of the endotracheal/tracheostomy tube, bronchial fibroscopy, all activities related to disconnection of the ventilator system, etc. Disconnection of the system can happen accidentally, e.g. when turning a patient for ventilation in prone position, therefore special precautions must be taken in such circumstances. Moreover, it should not be forgotten that the planned removal of the endotracheal tube is also a dangerous moment for the personnel and requires protection with PPE.

The intubation itself should be "planned" or "semi-planned", before the patient's condition necessitates "rescue" instrumentation of the respiratory tract, when there is no time to apply PPE accurately. It is worth considering putting on two pairs of gloves, so that immediately after intubation the outer glove could be used as a cover for the laryngoscope, which must be put in a resealable bag together with it; the inner gloves should be replaced as soon as possible [36, 37].

Table 2 summarizes the precautionary measures used during airway procedures.

One must remember not to touch the environment (the ventilator, the anesthesia apparatus, the tables) with dirty gloves, which often happens right after intubation and extubation [37].

After the SARS experiences in Toronto, it is known that a separate operating room should be

allocated for infected patients, clearly captioned, with negative pressure, with a clear prohibition of unnecessary entry. Adequate ventilation of the room should be provided with a minimum of 12 air exchanges per hour. During the transfer to and form the operating theatre the patient should be wearing a face mask and personnel should strictly follow the local PPE guidelines. Before and after any type of contact with the patient and before donning and after doffing of PPE, proper hand hygiene should be performed [38].

After surgery, the patient should be woken up and observed in the operating room or transported to the ICU whenever required [36, 39].

Regional anesthesia is preferred, and during the procedure the patient should always wear a mask. In the event of sedation, oxygen should be administered through the oxygen goggles placed under the mask. W przypadku znieczulenia ogólnego, in order to avoid aerosol formation during vomiting, antiemetic drugs should be routinely given. After extubation, the patient should have a mask put on and oxygen therapy should be applied as described above [40].

Moreover, another situation has to be mentioned, which poses a huge threat to ICU staff and is most often performed by anaesthesiologists, i.e. cardiopulmonary resuscitation (CPR). It may concern a patient with already confirmed infection, an isolated one, or not yet diagnosed one. The main hazard for staff is the aerosol formed during ventilation with a self-inflating bag; another problem is associated with quick protection with PPE, which can be problematic, almost certainly when resuscitation is carried out somewhere in a hospital and not in an isolated room. The number of persons involved in CPR should be reduced to minimum, with minimal, ideally none, involvement of other personnel [38].

Based on previous experience, it is known that the ways to reduce personnel exposure include apnoeic oxygenation or careful ventilation through a mask by two staff members, one of whom presses it tightly against the patient's face (with filter protection).

Early intubation is recommended. Use of mechanical chest compression devices reduces strain and minute ventilation in the personnel, which, in turn, reduces risk of inhalation of infectious aerosol; the risk of the protective mask shifting/slipping or hair getting out from under the cap is also reduced.

For patients already mechanically ventilated, in order not to disconnect the system and ventilate the lungs with a self-inflating bag, you can put the ventilator into a volume-controlled ventilation mode, with high peak inspiratory pressure (PIP) alarm threshold [41].

TABLE 2. Safety measures during instrumentation of the respiratory tract

Before the procedure
Carry out proper hand hygiene
Put on personal protective equipment according to the guidelines
• If possible, perform the procedure in a properly prepared and ventilated room
• Minimize the number of people in the room
• Prepare all necessary medicines and tools, make sure they are fit for use; remember about a video laryngoscope
• Present an action plan to other team members, make sure they understood
• Assess potential intubation difficulties
• Attach a filter to the self-inflating bag and ventilator system
Procedure
• It should be performed by the most experienced physician
• Preoxygenation using the smallest possible oxygen flow
• Adjust the face mask for ventilation so that there are no leaks
• Rapid induction (for sagging - succinylcholine or rocuronium) and avoidance of self-inflating bag ventilation (if possible)
• Ventilation of the lungs with positive pressure only after sealing the cuff of the endotracheal tube
• Avoid fiberoptic intubation if necessary and possible – use a disposable bronchoscope
After the procedure
• Avoid disconnecting the system
• If it is necessary to disconnect the system, wear PPE, apply sagging, seal the endotracheal tube
• Always adhere to the procedures of personal protective equipment removal and hand hygiene!

At the time of pandemias, the chance that an ICU physician will not come into contact with a sick patient is close to zero. Everyday practitioners dealing with respiratory instrumentation are at highest risk of infection, hence they must be aware of the dangers and strictly follow the procedures to prevent transmission of the virus to themselves.

CONCLUSIONS

Since the emergence of the first cases of infections in Wuhan, the virus has become the cause of a pandemia. Without knowledge about the ways in which Sars-CoV-2 spreads, the risks it poses for physicians, especially for ICU staff members, we will not be able to slow down the occurrence of new cases. The review discusses these issues, in particular those regarding the specifics of anesthesiology and intensive care; compliance with the recommendations gives a chance of success but, unfortunately, does not guarantee it.

As the article was being prepared, the number of the infected patients outside China increased sharply.

The world has faced an unprecedented health threat. Work is currently underway to find effective drugs and vaccines, but no positive results have been announced so far. In the anticipation of novel drugs and or vaccines, emphasis should be put on efforts focused on prevention and symptomatic management as well as mindful following of constantly updated evidence-based guidelines and research. These remain, to date, the only ways to contain the spread and mitigate the impact of the epidemic.

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REFERENCES

1. Chen L, Liu W, Zhang Q, et al. RNA based mNGS approach identifies a novel human coronavirus from two individual pneumonia cases in 2019 Wuhan outbreak. Emerg Microbes Infect 2020; 9: 313-319. doi: 10.1080/22221751.2020.1725399.
2. Cui J, Li F, Shi ZL. Origin and evolution of pathogenic coronaviruses. Nat Rev Microbiol 2019; 17: 181-192. doi: 10.1038/s41579-018-0118-9.
3. Wong ACP, Li X, Lau SKP, Woo PCY. Global epidemiology of bat coronaviruses. Viruses 2019; doi: 10.3390/v11020174.
4. Deng SQ, Peng HJ. Characteristics of a public health responses to the coronavirus disease 2019 outbreak in China. J Clin Med 2020; 10.3390/jcm9020575.
5. Han Q, Lin Q, Jin S, You L. Coronavirus 2019-nCoV: a brief perspective from the front line. J Infect 2020. doi: https://doi.org/10.1016/j.jinf.2020.02.010.
6. Drosten C, Günther S, Preser W, et al. Identification of a novel coronavoirus associated with severe acute respiratory syndrome. N Eng J Med 2003; 348: 1967-1976. doi: 10.1056/NEJMoa030747.
7. WHO. Middle East respiratory system coronavirus (MERS-CoV) – The Kingdom of Saudi Arabia; 2020. Available at: https://www.who.int/csr/don/24-february-2020-mers-saudi-arabia/en/.
8. Zhou P, Yang XL, Wang XG, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 2020; 579: 270-273. doi: 10.1038/s41586-020-2012-7.
9. Li W, Shi Z, Yu M, et al. Bats are natural reservoirs of SARS-like coronaviruses. Science 2005; 310: 676-679.
10. Wraap D, Wang N, Corbett KS, et al. Cryo-EM structure of the 2019-nCoV spike in the perfusion conformation. Science 2020; 367: 1260-1263. doi: 10.1126/science.abb2507.
11. Sun P, Lu X, Xu C, Sun W, Pan B. Understanding of COVID-19 based on current evidence. J Med Virol 2020. doi: 10.1002/jmv.25722.
12. Xu H, Zhong L, Deng J, et al. High expression of ACE2 receptor of 2019-nCoV on the epithelial cells of oral mucosa. Int J Oral Sci 2020. doi: https://doi.org/10.1038/s41368-020-0074-x.
13. Zhang H, Penninger JM, Li Y, Zhong N, Slutsky AS. Angiotensin-converting enzyme 2 (ACE2) as a SARS-CoV-2 receptor: molecular mechanisms and potential therapeutic target. Intensive Care Med 2020. doi: https://doi.org/10.1007/s00134-020-05985-9.
14. Wan Y, Shang J, Graham R, Baric RS, Li F. Receptor recognition by novel coronavirus from Wuhan: an analysis based on decade-long structural studies of SARS. J Virology 2020. doi: 10.1128/JVI.00127-20.
15. Tyrrell DAJ, Myint SH. Coronaviruses. In: Medical Microbiology. 4th ed. Baron S (ed.). Galveston (TX), University of Texas Medical Branch at Galveston; 1996. Chapter 60.
16. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020; 395: 497-506. doi: 10.1016/S0140-6736(20)30183-5.
17. Wu F, Zhao S, Yu B, et al. A new coronavirus associated with human respiratory disease in China. Nature 2020. doi: https://doi.org/10.1038/s41586-020-2008-3.
18. https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases. Situation update worldwide, as of 7 March 2020, 08:00.
19. Wang W, Tang J, Wei F. Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan, China. Med Virol 2020; 92: 441-447. doi: 10.1002/jmv.25689.
20. https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf
21. Young BE, Ong SWX, Kalimuddin S, et al. Epidemiologic features and clinical course of patients infected with SARS-CoV-2 in Singapore. JAMA 2020. doi: 10.1001/jama.2020.3204.
22. World Health Organization (WHO). Consensus document on the epidemiology of severe acute respiratory syndrome (SARS) 2003. Geneva: WHO; 2003. Available at: http://www.who.int/csr/resources/publications/CDS_CSR_ARO_2004_2.pdf.
23. Backer JA, Klinkenberg D, Wallinga J. Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20-28 January 2020. Euro Surveill 2020. doi: https://doi.org/10.2807/1560-7917.ES.2020.25.5.2000062.
24. https://www.who.int/news-room/q-a-detail/q-a-coronaviruses
25. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristic of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a desciprive study. Lancet 2020; 395: 507-513. doi: 10.1016/S0140-6736(20)30211-7.
26. Bouadma L, Lescure F, Lucet J, Yazdanpanah Y, Timsit JF. Severe SARS-CoV-2 infections: practical considerations and management strategy for intensivists. Intensive Care Med 2020. doi: https://doi.org/10.1007/s00134-020-05967-x.
27. Lippi G, Plebani M. Laboratory abnormalities in patients with COVID-2019 infection. doi: DOI: https://doi.org/10.1515/cclm-2020-0198. Availabel at: https://www.degruyter.com/view/j/cclm.ahead-of-print/cclm-2020-0198/cclm-2020-0198.xml#.
28. Liu J, Zheng X, Tong Q, et al. Overlapping and discrete aspects of the pathology and pathogenesis of the emerging human pathogenic coronaviruses SARS-CoV, MERS-CoV and 2019-nCoV. J Med Virol 2020; doi: 10.1002/jmv.25709.
29. https://cases.rsna.org/coronavirus
30. Jin YH, Cai L, Cheng ZS, et al. A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019 n-CoV) infected pneumonia (standard version). Military Medical Research 2020. Available at: https://mmrjournal.biomedcentral.com/articles/10.1186/s40779-020-0233-6.
31. Guan WJ, Ni ZY, Hu Y, et al.; China Medical Treatment Expert Group for Covid-19. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020. doi: 10.1056/NEJMoa2002032.
32. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med 2020. doi: https://doi.org/10.1016/S2213-2600(20)30079-5.
33. Ñamendys-Silva SA. Respiratory support for patients with COVID-19 infection. Lancet 2020. doi: https://doi.org/10.1016/S2213-2600(20)30110-7.
34. MacLaren G, Fisher D, Brodie D. Preparing for the most critically ill patients with COVID-19. The potential role of extracorporeal membrane oxygenation. JAMA 2020. doi: 10.1001/jama.2020.2342.
35. https://emcrit.org/pulmcrit/lopinavir/
36. Zucco L, Levy N, Ketchandji D, Aziz M, Ramachandran SK. Perioperative considerations for the 2019 novel coronavirus (COVID-19); 12.02.2020; doi: https://www.apsf.org/news-updates/perioperative-considerations-for-the-2019-novel-coronavirus-covid-19/.
37. Rowlands J, Yeager MP, Beach M, Patel HM, Huysman BC, Loftus RW. Video observation to map hand contact and bacterial transmission in operating rooms. Am J Infect Control 2014; 42: 698-701. doi: 10.1016/j.ajic.2014.02.021.
38. Peng PWH, Ho PL, Hota SS. Outbreak of a new coronavirus: what anaesthetists should know. Br J Anaesth 2020. doi: 10.1016/j.bja.2020.02.008.
39. Ti LK, Ang LS, Foong TW, Ng BSW. What we do when a COVID-19 patient needs an operation: operating room preparation and guidance. Can J Anaesth 2020. doi: 10.1007/s12630-020-01617-4.
40. Wong J, Goh QY, Tan Z, et al. Preparing for a COVID-19 pandemia: a review of operating room outbreak response measures in a large tertiary hospital in Singapore. Can J Anesth 2020. doi: https://doi.org/10.1007/s12630-020-01620-9.
41. Ling L, Joynt GM, Lipman J, Constantin JM, Joannes-Boyau O. COVID-19: a critical care perspective informed by lessons learnt from other viral epidemics. Anaesth Crit Care Pain Med 2020. doi: 10.1016/j.accpm.2020.02.002.