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Spirometry during the SARS-CoV-2 pandemic. Guidelines and practical advice from the expert panel of the Respiratory Pathophysiology Assembly of the Polish Respiratory Society

This guidance provides advice to healthcare workers on the use of spirometry during the SARS-CoV-2 outbreak. It has been developed based on currently available information and recommendations from relevant health care institutions. These recommendations are not based on scientific evidence (EBM, evidence based medicine), prospective studies, or research projects. This practical advice set will be kept under review and updated over time as new data becomes available.

Introduction

The first cases of COVID-19 disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) were described at the end of 2019 in Wuhan, Hubei Province, China. The rapid spread of the infection resulted in the World Health Organization announcing that the COVID-19 outbreak was a global pandemic on March 11th, 2020. The first case of SARS-CoV-2 infection in Poland was reported on March 4th, 2020 [1]. According to data from the Johns Hopkins Institute [2] dated September 1st, COVID-19 disease caused by the new SARS-CoV-2 coronavirus has been confirmed in over 25,5 million people worldwide, and the number of deaths has exceeded 850,000. In Poland, data from the Ministry of Health from early September indicates that there were over 67,000 infected individuals with the number of deaths exceeding 2000 [3]. At that time, 300–450 new cases were reported per day in Poland with most patients coming from groups of people working or living in close proximity (e.g., in workplaces and nursing homes). The daily morbidity rate during August

2020 increased to a range between 550–800 depending on which region of the country was being analyzed.

Current evidence suggests that the main routes of transmission of the SARS-CoV-2 virus are via inhalation, direct contact with contaminated surfaces, and transmission via the mucous membranes of the mouth, nose, and eyes. Aerosols containing the virus may spread up to 2 meters from an infected individual. As a result, this has culminated in many countries introducing social distancing in public spaces. However, studies have shown that the aerosol transmission distance of SARS-CoV-2 might be up to 4 or even 8 meters [4]. There are also reports suggesting that the virus can be transmitted through the air without being aerosolized [5, 6]. SARS-CoV-2 viral particles have been shown to survive for at least 3 hours when aerosolized and can maintain viability for up to 72 hours on a hard surface, albeit with a significantly reduced titer. The virus has been found to be more stable on plastic or stainless steel surfaces rather than on surfaces made of copper or cardboard [7].

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The SARS-CoV-2 virus has mainly been isolated from nasal and pharyngeal secretions and sputum. Viral material was also found in tears, stool, and blood of infected people, although the clinical significance of this is yet to be determined [8–10]. The maximum incubation period is assumed to be up to 14 days, and the median time to onset of symptoms is estimated to be at 5.1 days (95% CI 4.5–5.8 days). In approximately 2.5% of patients, symptoms appeared within 2.2 days following infection. In 97.5% of patients, they appeared within 11.5 days (range 2 to 14 days) [11]. It is important to emphasize that although symptomatic individuals pose the highest risk of transmission, it is also possible for an infected yet asymptomatic person to transmit the virus. The exact incidence of asymptomatic infections is not known. Most studies estimate the prevalence of asymptomatic transmission to range from 20% [12] to 40–45% [13], but some studies report a prevalence rate over 80% [14]. Such large discrepancies can be attributed to the lack of long-term observational data and the difficulty in differentiating between asymptomatic individuals and those who are pre-symptomatic patients in whom the infection was diagnosed before the appearance of COVID-19 symptoms. One study showed that 13% of cases could be caused by the spread of the disease in patients who were pre-symptomatic [15].

The clinical course of SARS-CoV-2 infection is diverse. In about 80% of patients, the illness is mild. In 14% of patients, the course is severe with dyspnea, hypoxemia, and >50% of lung parenchyma affected. In 5% of patients, the illness is critical with respiratory failure, shock, or multi-organ failure [16]. Mortality due to COVID-19 varies in different regions. Chinese authors estimate the overall mortality rate to be 2.3% with a significantly higher mortality rate (up to 14.8%) in those over the age of 80 [16]. In Italy, the overall mortality rate from COVID-19 was 7.2% during the pandemic's initial period [17]. In patients who became critically ill, the mortality rate was 61% in China [18], 50% in the USA [19], and 26% in one of the intensive care units in Lombardy, Italy [20].

The period of infectivity for individuals with SARS-CoV-2 infection has not yet been determined. It is important to note that the presence of viral genetic material in airway secretions is not synonymous with infectivity. The duration of viral RNA shedding varies greatly; however, it seems to be linked to illness severity. One study showed a higher probability of elimination of the virus within the first week following infection

in asymptomatic patients when compared with patients reporting COVID-19 symptoms [21]. In another study, the median time of clearance of the virus in patients with mild COVID-19 disease who did not require hospitalization in the ICU was estimated to be at 24 days (interquartile range 18–31 days). However, one study observed that the viral shedding duration was up to 42 days [22]. According to the *Centers for Disease Control and Prevention* (CDC), viral load in the upper respiratory tract begins to significantly decrease after the onset of symptoms [23]. Therefore, the probability of isolating an infectious form of the virus from the airway secretions of patients with mild to moderate COVID-19 disease 10 days after the onset of symptoms is very low. In severe to critical COVID-19 patients, the probability of detecting an infectious form of the virus decreases to < 5% 15.2 days after initial infection [24]. It is also possible to detect viral genetic material in the airway secretions of those who have had COVID-19 disease for up to 3 months after the initial infection occurred, albeit in much lower titers than during the illness. Isolation of an infectious form of the virus from these patients is usually not possible and, as a result, their infectivity is thought to be negligible [23].

The most common COVID-19 disease symptoms are cough, shortness of breath, and a fever above 38°C. Other symptoms that may suggest infection include myalgia, headache, dizziness, changes in sense of taste and/or smell, and gastrointestinal disturbances. Diagnosis of SARS-CoV-2 infection requires confirmation by a positive reverse transcriptase polymerase chain reaction (RT-PCR) test result.

Performing spirometry during the SARS-CoV-2 pandemic

The SARS-CoV-2 coronavirus is becoming increasingly widespread in society and poses a potential threat to staff and patients attending respiratory function laboratories. The incidence and infectivity of the virus, the Minister of Health's recommendations, the Chief Sanitary Inspector, and local infection control teams are of value in providing guidelines for taking adequate preventive measures.

Maintaining patients and healthcare professionals' safety is a priority. Therefore, extra precautions are required when performing respiratory function tests. All the necessary actions may lead to extended testing time, reorganization of diagnostic routines, a reduced number of

tests performed, and an increased consumption of disposable materials and personal protective equipment (PPE).

Generation of aerosols

Although there is no official position on this, respiratory function testing is considered an aerosol-generating procedure (AGP) [25]. An AGP is defined as any medical procedure which causes the generation of airborne particles (aerosols). Aerosols containing viral particles may remain suspended in the air for a while or travel for various distances and cause infection via inhalation or contact with mucous membranes. Therefore, AGPs harbor a risk of airborne transmission of infections that would typically only be transmitted by droplets [26].

Aerosol particle transmission

Airborne transmission of infectious diseases is possible by two routes:

1. Droplet transmission: expelled particles (diameter $> 5 \mu\text{m}$) that settle quickly and can only travel short distances (within 1 meter) from the source.
2. Aerosol transmission: expelled particles (diameter $\leq 5 \mu\text{m}$) which can travel much further.

In 2007, the World Health Organization (WHO) recommended the use of a $5 \mu\text{m}$ threshold to differentiate aerosol transmission (particle diameter $\leq 5 \mu\text{m}$) from droplet transmission (particle diameter $> 5 \mu\text{m}$) [27].

The WHO, CDC, and National Health Service (NHS) have agreed that the type of personal protective equipment required should be based on what transmission risks the person is exposed to. These include direct contact, fomites, aerosols, and/or droplets. According to the recommendations of the Agency for Health Technology Assessment and Tariff System (AOTMiT), “Protection against droplet spread also protects against contact transmission. Protection against airborne transmission protects against infection via droplets and/or the contact route” [28].

Performing functional testing of the respiratory system often involves forced respiratory maneuvers and generating an airflow of up to 14 L/s (840 L/min). During these maneuvers, similar to when coughing or sneezing, macro and micro-aerosols are produced containing secretions from the patient’s respiratory tract. These secretions may contain bacteria and viruses, including SARS-CoV-2 particles. Aerosols and droplets produced during spirometry become

suspended in the air and eventually settle on surfaces in the room such as equipment, furniture, and the floor. Therefore, there is a risk of infection from aerosolized particles and direct contact with contaminated surfaces for both patients and staff.

Various guidelines regarding pulmonary function testing specific to the COVID-19 pandemic have been published. These include guidelines from the 9.1 group (*Respiratory function technologists / Scientists*) of the *European Respiratory Society* (ERS) [29], the *American Thoracic Society* (ATS) [30, 31], and the *Association for Respiratory Technology & Physiology* (ARTP) [32–34].

Indications and contraindications for spirometry during the SARS-CoV-2 pandemic

- During the SARS-CoV-2 pandemic, spirometry and other lung function tests should be performed only if they are deemed necessary to diagnose and manage respiratory diseases. Tests should be carried out with additional safety measures in place in order to minimize the risk of infection transmission. Also, they should only occur in laboratories that can facilitate adequate distancing, isolation, room disinfection, etc.
- Lung function tests are likely to be necessary for the following indications [31]:
 - To diagnose and support management in patients who urgently need treatment initiation (e.g., COPD, IPF).
 - To evaluate patients who are candidates for surgical treatment due to lung cancer.
 - To assess patients undergoing surgery that require urgent assessment of lung function due to respiratory risk factors (e.g., respiratory disease, previous impairment in lung function, chest deformity, and/or severe obesity).
 - To study patients qualified for pharmacological treatment programs who are attending drug trials in which the assessment of respiratory function is crucial for therapeutic decisions.
 - Patients qualified for lung transplantation.
 - Urgent diagnostic procedures.
- Lung function tests should not be performed in patients with diagnosed or suspected SARS-CoV-2 infection or with symptoms suggestive of COVID-19 [29].
- ERS guidelines state that lung function testing should not be performed on patients diagnosed with SARS-CoV-2 infection for a minimum of 30 days post-infection [29].

- The ATS recommends that lung function tests can be performed after COVID-19 infection if the patient meets one of the following criteria:
 - No fever (without the use of fever-reducing medications), resolution of respiratory symptoms, and two negative RT-PCR swab test results (taken ≥ 24 hours apart).
 - No fever for at least 3 days (without the use of fever-reducing medications), a significantly decreased severity of respiratory symptoms, and ≥ 10 days since the onset of symptoms.
 - Asymptomatic with at least 2 negative RT-PCR tests obtained in the last 24 hours. Alternatively, ≥ 10 days since the previous positive RT-PCR test [31].
- In patients who are vulnerable to severe consequences from SARS-CoV-2 infection, lung function tests should be carried out in a room with negative pressure ventilation and without air conditioning, if possible [29].
- All routine respiratory function tests should be postponed until the end of the SARS-CoV-2 pandemic (this might be defined as a low viral prevalence and availability of reliable tests to exclude SARS-CoV-2 infection).
- Lung function tests should be limited to spirometry (preferably only performed during slow breathing [32] with a measurement of forced expiratory volume in one second [FEV₁] carried out in place of a forced expiration maneuver [flow-volume loop]), measurements of lung capacity and volume (if necessary) using body plethysmography, and diffusing capacity for carbon monoxide using the single-breath method.
- Procedures with significant aerosol generation potential (e.g., bronchial hyperresponsiveness testing, exercise testing [nb., the shuttle walk test and 6-minute walk test are recognized as procedures with decreased potential to generate aerosols], and reversibility testing) should not be performed [29].
- Every patient attending for lung function testing should be treated as a potentially infectious person.
- All referrals should be verified by an experienced physician. Where possible, the results of previously performed lung function tests should be taken into account and analyzed. An assessment should be made as to whether further testing will contribute to the current clinical picture.
- Tests that generate high aerosol levels should be substituted by alternative, less aerosol-generating procedures where clinically possible.
- SARS-CoV-2 RT-PCR test results should be documented in the patient's notes. Inpatients referred for respiratory function testing should have undergone testing on admission.
- Outpatients referred for respiratory function testing should undergo a health check questionnaire before performing any tests (p. 6). The ERS Group 9.1 suggests that screening for COVID-19 symptoms may be carried out by phone prior to laboratory attendance.

Guidelines for waiting rooms

All waiting rooms should have either passive ventilation (through open windows) or mechanical ventilation. Air recirculation systems and air conditioners should be avoided.

Non-essential items (e.g., brochures, posters, pillows, covers, curtains, decorations, drink dispensers, etc.) should be removed. Surfaces, including chairs, should be made of non-porous and easy to clean material. An alcohol-based hand gel or handwashing facilities with disposable paper towels should be available for patient use. The use of soap bars and reusable textile towels should be avoided. An information poster on hand hygiene and handwashing techniques should be displayed in a visible place.

The 9.1 ERS group [29] recommends keeping a minimum distance of 2 meters between patients. Patients are also recommended to attend alone and at an appointed date and time. If the patient requires a chaperone, it should be only one person who should also adhere to distancing and handwashing recommendations. Protective masks or visors should be worn when in the waiting room. It is advisable to create two separate waiting rooms for outpatients and hospitalized patients.

Laboratory organization

The time interval between successive patients should be long enough to allow for adequate

Organizational arrangements

As the SARS-CoV-2 infection can be transmitted by droplet transmission and by contact with contaminated surfaces and contaminated air [6, 33, 35, 36], significant adjustments are necessary in both the technique of testing and in the organization of laboratories that perform respiratory function tests. The Association for Respiratory Technology and Physiology (ARTP) [32] recommendations include:

Table 1. Agents with activity against SARS-CoV-2 [38]

Product	Concentration	Exposure time	Decrease in infectivity (\log_{10})
Ethanol	78%	30 s	≥ 5.0
2-propanol (isopropyl alcohol)	100%	30 s	≥ 3.3
	75%	30 s	≥ 4.0
	70%	30 s	≥ 3.3
	45% and 30%	30 s	≥ 4.3
2-propanol and 1-propanol (propyl alcohol)			
Formaldehyde	1%	2 min	> 3
Glutaraldehyde	2.5%	5 min	> 4
	0.5%	2 min	> 4
Iodopovidone	0.47%	1 min	3.8
	0.23%	1 min	> 4
Benzalkonium chloride	No data on efficacy are available — the product is not recommended		
Chlorhexidine digluconate	Ineffective		

ventilation of the room after each patient (at least 15 minutes), changing personal protective equipment by staff, and disinfection and recalibration of diagnostic equipment. This time interval is likely to last between 30–60 minutes.

Staff performing tests must use recommended PPE for aerosol-generating procedures following the national guidelines adopted from the AOTMiT which require [28]:

- A FFP3 or FFP2 half-face mask.
- Goggles or eye/face shield.
- A long-sleeved barrier apron (single-use or disinfectable and sterilizable).
- Disposable gloves, which should be discarded after each test and after cleaning of the laboratory.
- Hand hygiene, which should be performed before and after putting on and taking off PPE.
- If appropriate PPE is not available, testing should not be undertaken.

It is recommended that one examination is performed in one room at a time to reduce the risk of cross-contamination and infection of subsequent patients and staff. Where possible, protective screens should be used between patients and staff to minimize the risk of direct contact with aerosols [32]. The technician and the patient should avoid facing each other during breathing maneuvers to reduce the risk of the patients' exhaled air being directly inhaled by the technician.

Ventilation of rooms is crucial in order to reduce aerosolized viral particles. Ventilation involving just one air change has been found to

reduce the concentration of pollutants in the air (including SARS-CoV-2 particles) by 63%. After five air changes, less than 1% of air pollutants remain. Therefore, a ventilation system capable of performing 10–12 air changes per hour (ACH) would result in less than 1% of the initial air pollutants remaining after 30 minutes [33]. A room used for aerosol-generating procedures should have a ventilation system capable of at least 6 ACH. A room that does not meet this requirement, or if there are other significant concerns, should be left empty for at least three hours before cleaning [32].

Natural ventilation (e.g., open windows and doors) has been shown to be an effective way to reduce the concentration of viral particles in the air. In one study, natural ventilation increased the ACH value by up to 69%. The addition of an extractor fan in the window further increases the efficiency of a ventilation system [37]. Wherever possible, consider performing tests in alternate rooms and using an interval between testing for ventilation and disinfection [32].

Agents active against SARS-CoV-2 should be used when disinfecting rooms and equipment. A summary of common cleaning agents is presented in Table 1.

Conducting measurements

Single-use bacterial viral filters (BVF) have previously been recommended for use when performing routine spirometry, especially in patients with colonization of the airways with a known

pathogen or in patients who have a comorbid disease (e.g., tuberculosis or cystic fibrosis) to avoid cross-infection [39–41]. However, this was not a common practice.

In the advent of the COVID-19 pandemic, BVFs are now recommended for all functional respiratory testing [29, 33]. The filters should provide adequate filtration for flow rates of up to 600 to 700 L/min. Filtration efficiency depends on the filter fibers' density, the filter layer's depth, and the flow rate. Several factors must be considered when selecting filters:

- **Bacterial removal efficiency (BRE)** — the efficiency in trapping and removing bacterial and viral particles. Filters with an efficiency level of > 99.9% are recommended.
- **Airflow resistance** — the ATS recommends that the total airflow resistance at 14 L/s [42] must be < 1.5 cm H₂O per L per second, measured with the BVF in situ. The spirometer must be re-calibrated to account for the additional resistance with the BVF included and placed between the calibration syringe and the device [39].
- **Dead space volume** — the volume of dead space created by the filter should be as small as possible to minimize rebreathing, which is especially important in patients with small lung volumes (young children or patients with severe respiratory impairment). Currently available BVFs for functional testing have a dead space capacity of 50–75 mL.
- **Single-use BVFs** — they should be utilized. After testing, the filter should be disposed of according to local infection control procedures. The filter should not be retained for use with other patients or subsequent examinations with the same patient. For BVFs with reusable housing, the housing must be disinfected between patients according to local infection control procedures.
- **Type of BVF** — it is recommended to use a type of filter that fits multiple devices in a given laboratory. BVFs, which also act as a mouthpiece, can make it easier to clean the flow transducer, reduce the dead space created by a filter, and are of a lower cost. If a filter with a mouthpiece is used, there is no need to use an additional disposable mouthpiece [29].

Consistent use of a new BVF for each patient and routine cleaning of the device and surrounding environment with a disinfectant that has at least a 72% alcohol concentration are recommended to reduce the risk of equipment contamination and cross-infection.

When using equipment with disposable flow heads, compatible filters should also be used if the head has a physical connection with the pressure sensor(s). Additional filters are not required in devices where there is no connection between exhaled air and the rest of the apparatus (e.g., ultrasonic sensors). Compatible filters must be used to avoid affecting test results.

In order to reduce the number of unnecessary tests, improve efficiency, and shorten test time, each examination must be clearly explained to the patient. Technicians should not remove their mask to demonstrate breathing maneuvers to the patient, and the patient must breathe through the filter at all times.

Specific patient groups

Lung function testing in children

Overall, performing tests on children requires more significant staff input and more attempts than with adult patients. It is also more challenging to maintain distancing and sanitary regimes when working with children. During the COVID-19 pandemic, only essential examinations should be performed in children [43]. Indications for lung function testing in children include testing those with chronic diseases (e.g., cystic fibrosis, primary ciliary dyskinesia, uncontrolled asthma), during the qualification process for lung transplants or hematopoietic cell transplants, and in situations when the pathogenesis of a disease is unclear or requires special assessment.

In the context of COVID-19, the recommendations for testing children are consistent with the recommendations for adults. However, it should be noted that children, especially in younger age groups, are usually accompanied by an adult. Restrictions regarding distancing and hand hygiene must also be adhered to by the accompanying adult. Where possible, children should enter the examination room alone while the accompanying person remains outside. However, if a guardian must accompany the child, movement within the room and direct contact with equipment should be minimized.

Spirometry in the elderly

Older people with underlying diseases, including cardiovascular and chronic lung diseases, are known to be particularly susceptible to severe and critical effects of SARS-CoV-2 infection [18, 44]. Therefore, avoiding SARS-CoV-2 infection in this patient population is a priority, and visits to healthcare facilities should be avoided un-

less necessary with both routine and follow-up spirometry postponed until the post-pandemic period. Clinical circumstances and indications for spirometry should be discussed with the referring physician in terms of risk-benefit for the patient, and essential testing should be performed with all precautions mentioned above in place.

Spirometry in lung cancer patients

Patients with a malignancy who become infected with SARS-CoV-2 have a higher mortality rate than the general population, and lung cancer patients are particularly susceptible to severe SARS-CoV-2 disease. Additional risk factors such as old age, smoking, other cardiac and pulmonary conditions (e.g., COPD), and concurrent cancer therapy further increase this risk [45]. Among all cancer patients infected with SARS-CoV-2, those with lung cancer make up the largest group (21–25% of all patients) [46, 47].

One of the essential indications for respiratory function testing is evaluating lung cancer patients eligible for surgery. In these cases, the results of previously performed tests may be used to qualify for surgical treatment if the patients' clinical condition remains stable. However, if these are not available or the patient's clinical condition has deteriorated, spirometry should be performed with all the appropriate precautions.

Telemedicine

Emerging technological advancements such as telemedicine are being utilized more often due to the SARS-CoV-2 pandemic. Telemedicine can be used for consultations, remote monitoring of vital signs (e.g., ECG, blood pressure, and oxygen saturation), and monitoring of test results to reduce the risk of infection associated with physically being in a hospital. Telemedicine may be useful in the monitoring and follow-up of patients with long-term respiratory conditions (e.g., cystic fibrosis and severe asthma). However, it should not be used as a diagnostic tool instead of lung function testing [48].

Hospital procedure

Consistent rules or standard operating procedures (SOPs) that are easy for staff to follow are essential for the organization and delivery of lung function testing with minimal SARS-CoV-2 infection risk. An example of an SOP is shown in Appendix 1. The document has been prepared by members of the Clinical Department

of Pulmonology and Allergology team at the University Hospital in Cracow (which was designated a dedicated COVID-19 center). The SOP includes a description of the procedure, information regarding the organization of tests, staff protection, infection control, and instructions on safely performing lung function testing (Appendix 1). The hospital procedure goes with the health assessment questionnaire (Appendix 2).

Conflict of interest

None declared.

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Appendix 1. A standard operating procedure (SOP) [29, 49]

Rules for lung function testing during the state of epidemic emergency due to SARS-CoV-2 virus	
1. Aim and scope	<p>The aim of the procedure is to determine the procedure and method of performing lung function tests in the Pulmonary Function Lab during the state of epidemic emergency due to SARS-CoV-2 virus.</p> <p>It is obligatory for medical personnel..... to adhere to this procedure</p>
2. Definitions and terminology	<p>COVID-19 — an acute respiratory infection caused by SARS-CoV-2 virus.</p> <p>Lung function tests — used to identify the severity of pulmonary impairment and, inter alia, diffusion of gases in the alveoli.</p>
3. Responsibilities and powers	<p>The procedure applies to medical personnel as per their respective responsibilities.</p> <p>Qualification of the patient and completion of the questionnaire — a ward/clinic physician who refers to lung function testing.</p> <p>Performing pulmonary function tests — nursing staff of the Pulmonary Function Lab</p>
4. Description of the procedure	<p>Pulmonary function testing is an aerosol-generating procedure. During the test, secretions from the patient’s airways often spread between people interacting in close proximity as a result of the forced exhalation maneuver and coughing that may accompany it. This procedure carries the risk of spreading the infection to other people. It poses a serious risk to the health and safety of staff performing the tests as well as other patients.</p> <p>1. During the COVID-19 pandemic, performing lung function tests should be limited only to those cases where the outcome is essential to further patient management.</p> <p>2. Under no circumstances should pulmonary function tests be performed in patients with suspected or confirmed COVID-19. In patients with COVID-19, such tests may be performed after two consecutive negative swab test results and 30 days after the infection.</p> <p>3. Patients must present a referral form and the “Patient Health Assessment Questionnaire” completed by the referring physician (Appendix 2).</p>
4.1. Organization of work	<p>1. Prior to referral, the referring physician should assess current health state of the patient, according to the patient’s health assessment questionnaire (Appendix 2).</p> <p>2. In the waiting room, patients should wear face masks and sit at least 2 m away from each other.</p> <p>3. After each test, a break (30–60 min) should be provided, intended for:</p> <ul style="list-style-type: none"> — cleaning / decontamination of equipment and the environment, — ventilation of the room (15 min), — removing and putting on personal protective equipment by the staff, — recalibration of the device.
4.2. Staff protection	<p>1. It is mandatory for the staff to wear personal protective equipment in the test room. It is forbidden to wear it outside of the room.</p> <p>2. A separate room should be designated for staff’s changing into personal protective equipment and the second one for performing the tests.</p> <p>3. Plexiglas screens should be placed between the patient and the personnel while performing the tests.</p> <p>4. Use:</p> <ul style="list-style-type: none"> — FFP3 or FFP2 half-face masks, — goggles or eye/face shields, — long sleeve protective apron (additional plastic apron, which should be discarded after each patient encounter in units of particular risk) — disposable gloves to be discarded after each patient encounter and after cleaning the room’s surfaces. <p>5. Hand hygiene (washing and disinfection) is mandatory before and after removal of gloves.</p>



4.3. Performing pulmonary function tests

1. Lung function tests should be limited to spirometry and diffusing capacity of lung for carbon monoxide (DLCO) testing.
2. Body plethysmography should be used only when necessary due to the risk of contamination of the plethysmograph.
3. Cardiopulmonary exercise testing, bronchial challenge tests and nebulization therapy should not be performed due to aerosol generation.
4. Disposable mouthpieces with high-quality filters should be used, other consumables e.g. nose clips should also be used only once. If used more than once, they should be thoroughly cleaned according to local infection control guidelines.

4.4. Cleaning and infection control

1. Strictly follow the guidelines for disinfection of equipment, according to local infection control guidelines, ventilate the rooms and use ultraviolet (UV) light sanitizing systems such as germicidal lamps as often as recommended by local authorities.
2. Specific local guidelines for infection control must be followed.

5. Annexes

Patient health assessment (Appendix 2).

Appendix 2. Health assessment questionnaire

Patient name				
Contact number				
Full name of the referring doctor				
Contact number				
Date and time	Temperature	Oxygen saturation	RT-PCR SARS-CoV-2 (date)	
			Positive (+)	Negative (+)
History			YES	NO
Previous contact with a person with confirmed SARS-CoV-2 infection				
Clinical features of respiratory infection in the past 14 days				
Contact with a medical professional in the past 14 days				
Symptoms that occurred 14 days before the examination			YES	NO
	Cough			
	Dyspnea			
	Body temperature $\geq 38^{\circ}\text{C}$			
	Muscle or bone pain			
	Sore throat			
	Headache or dizziness			
	Nausea or vomiting			
	Diarrhea or loss of appetite			
	Change in the sense of taste or smell			
	Conjunctivitis			
	Other symptoms (skin lesions, cyanosis of fingers or toes)			

Actions are taken (select one option)

	YES	NO
SARS-CoV-2 infection suspected; Conduct a swab test and isolate while awaiting the result		
SARS-CoV-2 infection not suspected; Swab test not required		
Name and surname of the interviewer		
Patient signature		