

Expert panel consensus statement on the applications and precaution strategies of bronchoscopy in patients with COVID-19

Huizhen Yang^{1,2,*}, Huidong Chen^{3,*}, Baoan Gao⁴, Weining Xiong⁵, Xiaoju Zhang¹, D. Kyle Hogarth⁶, Jiayuan Sun^{2,7,*}, Mingyao Ke^{8,*}, Felix J. F. Herth⁹

¹Department of Respiratory and Critical Care Medicine, Henan Provincial People's Hospital, People's Hospital of Zhengzhou University, Zhengzhou, Henan Province, China; ²Department of Respiratory Endoscopy and Respiratory and Critical Care Medicine, Shanghai Chest Hospital, Shanghai Jiao Tong University, Shanghai, China; ³Department of Respiratory Endoscopy, Jinyintan Hospital of Wuhan, Wuhan, Hubei Province, China; ⁴Institute of Respiratory Disease, China Three Gorges University, Yichang Central Hospital, Yichang, Sichuan Province, China; ⁵Department of Respiratory and Critical Care Medicine, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China; ⁶Department of Medicine, University of Chicago Medicine, Chicago, IL, USA; ⁷Shanghai Engineering Research Center of Respiratory Endoscopy, Shanghai, China; ⁸Department of Respiratory Centre, The second Affiliated Hospital of Xiamen Medical College, Xiamen, Fujian Province, China; ⁹Department of Pneumology and Critical Care Medicine, Thoraxklinik, University of Heidelberg, Heidelberg, Germany

ABSTRACT

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a novel coronavirus with higher transmissibility compared with SARS coronavirus (SARS-CoV) and Middle East respiratory distress syndrome coronavirus. Coronavirus disease 2019 (COVID-19) caused by SARS-CoV-2 is an unprecedented global crisis that has not been experienced, which is still disrupting health systems, economies, and societies around the world by the rapid spread. Bronchoscopy plays an important role in diagnosis and therapy of pulmonary diseases, especially in patients with severe pulmonary infection, however, application of bronchoscopy in patients suspected or confirmed SARS-CoV-2 infection is extremely limited for the potential airborne transmission from aerosol generated during the procedure. This consensus statement was completed by expert panel of Interventional & Minimally Invasive Respiratory Committee of China Medical Education Association, and the issues were summarized as seven key topics to define the indications of bronchoscopy and matters needing attentions on the bronchoscopy procedures in patients with COVID-19, as well as the protective precaution strategies to avoid nosocomial SARS-CoV-2 infection.

Key words: bronchoscopy, consensus, coronavirus disease 2019

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*These authors contributed equally to this work; Dr. Huizhen Yang and Dr. Huidong Chen considered as co-first authors

Address for correspondence

Dr. Jiayuan Sun, Department of Respiratory Endoscopy and Respiratory and Critical Care Medicine, Shanghai Chest Hospital, Shanghai Jiao Tong University, No. 241 West Huaihai Road, Shanghai 200030, China.

E-mail: xkyjysun@163.com

Dr. Mingyao Ke, Respiratory Centre, The Second Affiliated Hospital of Xiamen Medical College, 566 Shengguang Road, Xiamen 361000, China.

E-mail: 13860166866@163.com

Dr. Felix J. F. Herth, Department of Pneumology and Critical Care Medicine, Thoraxklinik, University of Heidelberg, No. 1 Röntgenstr Street, Heidelberg 69126, Germany.

E-mail: felix.herth@med.uni-heidelberg.de

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INTRODUCTION

A series of highly infectious pneumonia cases of unknown cause began the focus of public health events in December 2019. On January 3, 2020, the first complete genome of the novel β genus coronaviruses (2019-nCoVs) was identified in samples of bronchoalveolar lavage fluid (BALF) from a patient from Wuhan by scientists of the National Institute of Viral Disease Control and Prevention through a combination of Sanger sequencing, Illumina sequencing, and nanopore sequencing.^[1-3] The novel coronavirus, was renamed as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2),^[4] and the disease caused by SARS-CoV-2 was defined as Coronavirus Disease 2019 (COVID-19) by WHO in February, 2020.

Research shows that SARS-CoV-2 enters the cell through the angiotensin-converting enzyme 2 receptor cell receptor for cell invasion in the same way as the SARS coronavirus.^[5,6] Due to sustained human-to-human transmission, the population is generally susceptible to this coronavirus, the rapid spread of SARS-CoV-2 results in an internationally formidable outbreak. On 11 March 2020, WHO characterized COVID-19 as a pandemic, which has brought significant impact on the health systems, economies, and societies around the world.

Rapid diagnostics, vaccines, and therapeutics are important interventions for the management of the COVID-19 outbreak. Unfortunately, no approved vaccines or antiviral treatments is available up to now, and the “false negative rate” of confirmation test for SARS-CoV-2 is too high. Currently, the major approach to this disease is to control the source of infection; use of personal protective precaution to reduce the risk of transmission; early diagnosis, isolation, and supportive treatments of complication for patients with COVID-19.^[7] Complications including severe pneumonia, respiratory failure, and acute respiratory distress syndrome (ARDS) have been reported,^[2,6] which may require tracheal intubation and mechanical ventilation in an emergency.

Bronchoscopy is a useful technique for the etiological diagnosis of infection^[8,9] and airway management of severe pneumonia,^[10-12] which has been extensively applied in clinical works. However, application of bronchoscopy in patients with COVID-19 was extremely limited and only be recommended in certain

necessary conditions for the higher transmissibility of SARS-CoV-2.^[6,13-15] Data of a research shows that 29% of 138 hospitalized patients with COVID-19 were health-care workers.^[7] Therefore, it is important to define the indications and specific approaches of bronchoscopy in patients with SARS-CoV-2 infection, as well as medical protective precaution strategies for reducing exposure to the virus of patients and health-care workers. This consensus statement covers common and important situations in the application of bronchoscopy in patients with COVID-19, and some relevant challenging queries in clinical practice are being stated.

KEY TOPICS ON APPLICATIONS OF BRONCHOSCOPY AND PRECAUTIONS IN THE PROCEDURE FOR PATIENTS WITH COVID-19

Individual members submitted questions, based on their experience as experts in bronchoscopy, pulmonary medicine, critical care medicine and SARS-CoV-2 infection. The seven topics that summarized the most pressing issues with bronchoscopy were selected for discussion.

DIAGNOSTIC ROLE OF THE BRONCHOSCOPY IN PATIENTS WITH COVID-19

Recommendation

Bronchoscopy is not a routine sampling method for testing SARS-CoV-2, and less invasive diagnosis specimens are recommended to be tested first in suspected COVID-19 patients. Bronchoscopy could be employed in certain situations, including highly suspected SARS-CoV-2 infection with the repeated negative results of upper respiratory tract specimens, clinical outcomes being dissatisfied, or other pulmonary diseases even emergencies affecting the treatment decision of COVID-19 being suspected.

Etiological evidence of SARS-CoV-2 infection is the gold standard for confirmation of suspected COVID-19. Reverse transcription polymerase chain reaction (RT-PCR) and next-generation sequencing (NGS) technology have been employed to test the nasopharyngeal swabs, sputum, lower respiratory tract aspirations, BALF, blood and stool of suspected COVID-19 patients.^[3,4,7] Because most

patients with COVID-19 complain cough without sputum, qualified sputum or lower respiratory tract aspiration is difficult to obtain. Nasopharyngeal swab specimens is recommended to test SARS-CoV-2 because of its quick and convenient access. However, specimens (BALF, brushing, *etc.*) obtained by bronchoscopy from lower respiratory tract are still the ideal specimen for testing SARS-CoV-2, because bronchial epithelial cells and alveolar epithelial cells have a higher viral load.^[2,5]

SARS-CoV-2 has potentially higher transmissibility (R_0 : 1.4–5.5) than that of both SARS coronavirus (SARS-CoV) (R_0 : 2–5) and Middle East respiratory distress syndrome coronavirus (R_0 : <1),^[6,7] and a large number of contagious aerosols will be produced in the process of invasive operation (including bronchoscopy) for patients with COVID-19. In view of this situation, bronchoscopy is not recommended as a routine sampling method for testing SARS-CoV-2. However, for patients highly suspected of COVID-19 on the basis of epidemiologic history, symptom, laboratory examination and CT findings, if repeated testing results of multiple specimens (nasopharyngeal swab, sputum and stool) for SARS-CoV-2 is negative, BAL can be performed cautiously for definite diagnosis, avoiding the patient becoming a concealed-spreader.

Previous researches show that bronchoscopy is a useful and safe diagnostic tool for obtaining etiological diagnosis in ventilator-associated pneumonia (VAP) and non-resolving pneumonia.^[6,11] In patients infected with SARS-CoV-2, half of non-survivors experienced a secondary infection, and VAP occurred in 31% patients requiring invasive mechanical ventilation.^[3] Therefore, bronchoscopy may provide qualified BALF and brushing specimens for microbiological examination in patients with COVID-19 when the infection was not improved or even aggravated. It is not recommended to perform BAL in critical patients infected with SARS-CoV-2 but without tracheal intubation, otherwise the situation may be worsened by the bronchoscopy procedure.

When other pulmonary diseases even emergencies occurred in patients with COVID-19, such as acute respiratory failure caused by central airway stenosis or foreign body aspiration, severe hemoptysis of airway, bronchoscopy could be performed in the ward to check the airway immediately and provide efficient solutions for the situations if possible.

FACTORS IMPACTING THE DIAGNOSTIC YIELD OF BRONCHOSCOPY FOR TESTING SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2

Recommendation

BALF and brushing specimens are often being obtained to improve the diagnostic yield of bronchoscopy for testing SARS-CoV-2 infection, even biopsy could be considered for differential diagnosis if necessary. Obtaining location, quality, handling and processing of bronchoscopy specimens, as well as the accuracy of test methods are important factors for impacting the diagnostic yield of testing SARS-CoV-2. Because these factors are related with RNA extraction which will impact the detection of virus markedly. It is suggested to select target lesions of performing bronchoscopy on the basis of chest CT images. In some procedures of bronchoscopy (brushing or biopsy of GGOs, *etc.*), if accurate localization of peripheral pulmonary lesions (PPLs) is unsatisfactory by chest computed tomography (CT) images, radial endobronchial ultrasound (R-EBUS) could help to detect target lesions with “blizzard sign” or “mixed blizzard sign” echoic features.

BAL and bronchial brushing are safe and efficient diagnostic techniques for pulmonary infection^[16] and often being used to establish the diagnosis of SARS-CoV-2 infection. After bronchial brushing being completed, it is suggested to rinse the Protected Specimen Brush in 5 ml of sterilized physiological saline and collect the fluid specimen for testing SARS-CoV-2. Furthermore, when other diseases are suspected in patients with SARS-CoV-2 infection which may affect the treatment decision for COVID-19, even biopsy could be considered for differential diagnosis if necessary.

Nonspecific abnormal findings were found on chest CT images of patients with COVID-19, often including multiple patchy shadows, ground-glass opacity (GGO) or subsegmental consolidation mainly located in peripheral area.^[3,7] In the early stage, there are obvious patchy shadows and GGOs in the extrapulmonary zone, and then developed in to lung consolidation even pleural effusion in severe cases. It is recommend to obtain specimens from the areas of patchy shadows and GGOs on CT images, which indicate the new lesions of SARS-CoV-2 infection. For the diffuse lesions of

both lungs, it is easy to perform BAL in right middle lobe and left lingual segment, and percent fluid recovery of which is greater.^[17,18] Conventional bronchoscopy has difficulty in reaching the exact location of the lesions in the peripheral lung, and if accurate localization of PPLs is unsatisfactory by chest CT images, R-EBUS could be used to select a satisfactory area for obtaining BALF, brushing, or even biopsy specimens.

R-EBUS is a useful tool for precise localization of PPLs, and EBUS features (noncontinuous margin, absence of a linear discrete air bronchogram and heterogeneous echogenicity) are informative in predicting malignant PPLs.^[19] In contrast, continuous margin, presence of a linear discrete air bronchogram and homogeneous echogenicity are echoic features of benign diseases (pulmonary infection, obstructive pneumonia, *etc.*), which will present in consolidation areas on chest CT images of patients with COVID-19. Moreover, characteristic of pure GGO lesions or part-solid GGOs on EBUS images is “blizzard sign” or “mixed blizzard sign,”^[20] which will be detected in patchy shadows or GGO-predominant areas on chest CT images of patients with COVID-19.

When bronchoscopy is intended to be performed in patients suspected of COVID-19, patchy shadows or GGO-predominant areas are better than consolidation areas to obtain specimens for testing SARS-CoV-2. R-EBUS could accurately select the areas with obvious “blizzard sign” or “mixed blizzard sign” on ultrasound image, guiding the operator to perform bronchoscopy in the suitable subsegment for qualified specimen.

Appropriate suction pressure (low than 100 mmHg), percent fluid recovery larger than 30% and silicified plastic or glass container are recommended to ensure the quality of BALF. The quantity of BALF should be more than 5 ml, and the specimens should be delivered to the microbiology laboratory immediately at room temperature. Prompt processing of the BALF provides optimal results. Cellular analysis (cell count and cell differential), aspergillus galactomannan antigen, and special staining of BALF are recommended to be carried out for differential diagnosis, if clinically indicated.^[16-18] Cell count could be used for the quality evaluation of BALF. Qualified test kits of RT-PCT or NGS should be employed for improving the diagnostic accuracy of SARS-CoV-2.

VALUE OF BRONCHOSCOPY IN AIRWAY MANAGEMENT IN PATIENTS WITH COVID-19

Recommendation

Airway management strategy is important for the clinical outcomes of critical patients with COVID-19. Bronchoscopy is recommended to be employed in assistance of tracheal intubation and tracheotomy, to ensure a rapid and accurate artificial airway establishment in patients with COVID-19, especially in the difficult airway. Checking airway condition by bronchoscopy could clear the obstruction efficiently under direct vision, provide messages for adjusting ventilator parameters, and improve the success rate of removing the ventilator and pulling-out endotracheal tube.

COVID-19 onset may result in progressive respiratory failure owing to alveolar damage (as observed by chest CT images),^[5] and perfect airway management strategy is crucial for the clinical outcomes.^[3] Value of bronchoscopy in establishment and management of artificial airway (tracheal intubation and tracheotomy) in patients with COVID-19 is detailed as follows.

Under the support of high-flow nasal cannula oxygen therapy or noninvasive ventilation, ARDS still exists or even acutely deteriorates, tracheal intubation and mechanical ventilation should be implemented in patients infected with SARS-CoV-2 as soon as possible,^[14] and tracheotomy should be considered when tracheal intubation has been applied for 2 weeks or more. Due to high grade medical protective precautions, additional operation difficulties and insufficient medical care may emerge, for example, auscultation by conventional stethoscope for confirming tracheal intubation position and palpation for surface landmarks during tracheotomy being hardly performed, as well as airway managements being relatively limited, *etc.* Efficient airway management strategy and guiding technique to ensure a rapid and accurate artificial airway establishment for critical patients with COVID-19 are in great demand. Confirmation by bronchoscope is the gold standard of successful tracheal intubation, and intubation guided by bronchoscope is recommended in difficult airway, which will reduce the risk of severe hypoxia during intubation. Bronchoscope could help adjust the tracheal intubation at the best depth for ventilation, avoiding the one-lung ventilation or prolapse of intubation associated with inappropriate intubation depth. Bronchoscopy could assist to determine the best site for percutaneous dilation

tracheotomy (PDT) and provide real-time monitoring during the operation. Among the tracheotomy methods for patients with COVID-19, PDT is preferred to conventional or surgical open tracheotomy, for reducing the virus-aerosol dispersion.

Airway management is extremely important for critical patients with COVID-19. After the artificial airway being established with the assistance of bronchoscope, immediate bronchoscopy could be performed subsequently to investigate the definite condition of lower respiratory tract (including presence of secretions/pus, appearance of bronchial mucosa, *etc.*). Early bronchoscopy for clearance of secretions/pus blocking the bronchial lumen could relieve the obstruction efficiently and is beneficial for the ventilation. In patients with COVID-19 combined with chronic obstructive pulmonary disease or secondary infection, more secretions or blood arising may induce obstructive atelectasis, while the bronchoscopy could clear the obstruction efficiently under direct vision. Complications associated with prolonged tracheal intubation or tracheotomy, including fistula, stenosis or granulation hyperplasia, and mucosal hemorrhage, may occur in patients with COVID-19, which could be detected timely through bronchoscopy and be solved effectively by interventional therapy of bronchoscopy.

If ventilator alarms are encountered in the process of mechanical ventilation, such as high peak airway pressure and low minute ventilation volume, bronchoscopy can directly remove airway blocking and provide messages for adjusting ventilator parameters subsequently.

Checking airway condition by bronchoscopy could improve the success rate of removing the ventilator and pulling-out endotracheal tube. When ventilator was difficult to be removed or endotracheal tube was failed to be withdrawn from patients with COVID-19, bronchoscopy could help find the reasons (laryngeal edema, vocal cord paralysis, airway stenosis, secondary infection, *etc.*) and solutions for the failure.

SUGGESTIONS ON PROCEDURES OF THE BRONCHOSCOPY IN THE PATIENTS WITH COVID-19

Recommendation

Flexible electronic or fiberoptic bronchoscope is recommended to be used in patients with COVID-19,

while fiber bronchoscope without screen is not suggested, because operator wearing eye protection could not see the bronchoscope vision through eyepiece. Single-use disposable bronchoscope is recommended to be used first line in COVID-19 for its portability and less contamination. Use of rigid bronchoscope is avoided. It is advised to reduce the lavage volume, minimize unnecessary procedures and shorten operation time moderately in order to avoid aggravating respiratory failure.

Flexible electronic or fiberoptic bronchoscope is recommended to be used in patients with COVID-19, while fiber bronchoscope without screen is not suggested, because operator wearing eye protection could not see the bronchoscope vision through eyepiece. It is necessary to avoid the use of rigid bronchoscope for operation as much as possible because more virus-aerosol will be generated in the open ventilation environment.

Using contaminated bronchoscopes that have physical defects and harbor viruses, bacteria, or fungi will put vulnerable patients at risk of bronchoscopy-associated pathogen transmission and result erroneous BAL test results.^[21] Single-use portable disposable bronchoscopes have been evaluated in the critical care setting with favorable evaluation for bronchoscopy, tracheotomy, tracheal intubation and suction,^[22,23] and have been recommended to be used first line in patients with COVID-19.^[21,24] However, it is recommended to use reusable electronic bronchoscopes for advanced and complicated interventional therapies of bronchoscopy, because the poor visibility and controllability of single-use bronchoscopes might induce operator to suffer excessive fatigue in operations and even delay of emergency condition (such as severe hemoptysis of airway, foreign body aspiration).

Because of patients infected with SARS-CoV-2 often having no obvious secretion, obtaining BALF for diagnosis is the main purpose of bronchoscopy other than lavage therapy, therefore, it is suggested to reduce the lavage volume moderately to avoid aggravating respiratory failure by excessive lavage. All equipment and items should be fully prepared before starting the procedure, such as bronchoscope, negative suction drainage, specimen container, anesthetic medicines and first aid medicines, alcohol gauze for disinfecting the bronchoscope, and so on. During operation, vital signs of patients should be closely monitored, if the blood oxygen saturation drops significantly, the bronchoscope

should be pulled out quickly, and the operation could be continued after the blood oxygen saturation is restored. It is recommended to shorten operation time and minimize the procedures may affecting pulmonary function of patients.

SUGGESTIONS ON ANALGESIA AND MECHANICAL VENTILATION OF THE PATIENTS WITH COVID-19 UNDERGOING BRONCHOSCOPY

Recommendation

Virus aerosol with higher viral load from lower respiratory tract of patients with COVID-19 will spray out when patients cough and closed ventilation circuit is opening at the same time during the bronchoscopy. All bronchoscopy related operations should be performed under sufficient sedation and analgesia to decrease responses of patients, muscle relaxation sometimes is necessary. For mild patients with no emergency, mechanical ventilation is not necessary. For critical patients with mechanical ventilation, closed positive pressure mechanical ventilation with filter is recommended. Volume control mode and 100% oxygen concentration of ventilator are recommended during the process of bronchoscopy.

When patients cough and closed ventilation circuit is opening at the same time during the bronchoscopy, virus aerosol with higher viral load from lower respiratory tract may spray into the air, on the body of health-care workers, on the surface of equipment and items, which will result in potential transmission of SARS-CoV-2. Therefore, all bronchoscopy-related operations in patients with COVID-19 should be performed under sufficient sedation and analgesia, muscle relaxation sometimes is necessary. Depth of sedation and analgesia should be strengthened to decrease responses (irritating cough, restlessness, *etc.*) to the stimulation of bronchoscopy.

For mild patients with no emergency but confirming diagnosis of COVID-19 by bronchoscopy being demanded, it is recommend to perform bronchoscopy through ventilator mask with filter and operation channel for bronchoscope [Figure 1a]. Alternatively, bronchoscopy can be operated directly through the nasal cavity with patient wearing medical protective mask, and continuous suction by inserting a negative pressure suction device into the oral cavity could reduce the laryngopharngal secretions retention [Figure 1b].



Figure 1. Performing bronchoscopy in mild patients suspect of COVID-19. (a) performing bronchoscopy through ventilator mask with filter and operation channel for bronchoscope. (b) Performing bronchoscopy through the nasal cavity with patient wearing medical protective mask, and continuous suction by inserting a negative pressure suction device into the oral cavity

Therefore, when mechanical ventilation is not necessary in mild patients with COVID-19, inhalation of pure oxygen through mask or nasal tube could provide adequate oxygen supply during the bronchoscopy. For patients with COVID-19 having been applied with mechanical ventilation, closed ventilation with filter is recommended during performing bronchoscopy, in order to minimize the transmission of virus-aerosol. Some adjustments should be taken on the parameters of ventilator to reduce the risk of hypoxia during the process of bronchoscopy, including ventilation mode being adjusted into volume control mode and ventilator oxygen concentration being increased to 100%.

When the use of rigid bronchoscope is inevitable, open jet ventilation should be avoided and classic positive pressure mechanical ventilation (closing all of proximal openings of rigid bronchoscope, and sealing the gap around the rigid bronchoscope with gauze bandage) is suggested, in order to ensure a relatively closed ventilation environment.

PROTECTIVE PRECAUTION STRATEGIES TO CONTROL THE BRONCHOSCOPY-RELATED NOSOCOMIAL INFECTION OF SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2

Recommendation

Specific place of operation, high grade self-protection, well-experienced in skills, less virus-aerosol

dispersion, as well as the cleaning and disinfection of equipment and items are important factors to control the nosocomial infection of SARS-CoV-2. Hand hygiene and medical protective precautions should be carried out in all steps of bronchoscopy-related operations (including specimen handling and transport, cleaning and disinfection of instrument and equipment related to the operation, terminal disinfection of rooms, *etc.*).

Bronchoscopy should be performed in a specific negative pressure ward or single room with well ventilation, at least in a single isolated room if no condition. Operator and assistants should carry out enhanced third-degree protection, including wearing protective glasses or face shield (anti fog type), medical protective N-95 respirator, protective clothing, gloves *etc.*, and it is recommended to use the dynamic positive pressure air purification head cover device if possible. All participants should be well-experienced in skills and have received strict self-protection training. It is recommended to simplify bronchoscopy process, shorten operation time and minimize number of essential participants as far as possible.

In order to reduce the virus-aerosol dispersion during the operations, it is suggested to reduce the times of pulling out bronchoscope from endotracheal tube. When the bronchoscope is being pulled out, alcohol gauze should be used to disinfect and plug the hole of tee junction. Cleaning the surface of bronchoscope by alcohol gauze and flushing the channel of by suction of alcohol should be performed firstly before disinfection.

Rules and regulations for aseptic operation should be strictly followed to prevent secondary infection. Disposable bronchoscopes should be used first line when available, which will reduce bronchoscope-related contamination of patients and avoid virus aerosol transmission during the disinfection of bronchoscope. Reusable conventional bronchoscopes should follow standard high-level disinfection.^[24] Hand hygiene and medical protective precautions should be carried out in all steps of bronchoscopy-related operations (including specimen handling and transport, cleaning and disinfection of instrument and equipment related to the operation, terminal disinfection of rooms, *etc.*). Laboratory personnel processing and testing specimen regarding SARS-CoV-2 infection should be alerted.

RESEARCH ADVANCES IN THE BRONCHOSCOPY FOR PATIENTS WITH COVID-19?

Recommendation

Robotic System of bronchoscope intending for patients with COVID-19 has been developed, and the operator could perform bronchoscopy via remote control, which could satisfy the diagnostic and therapeutic need of patients with COVID-19 and protect the operator from infectious environment by spatial isolation. Operations completed by remote controlled manipulators across distance boundaries may be the focus of clinical researches in future. Artificial intelligence may contribute to the development of bronchoscopy for patients with COVID-19.

A variety of robotic equipment (such as temperature monitoring robot, disinfection robot, foods and drugs delivery robot, and so on.) have been used in patients with COVID-19. Robotic System of bronchoscope intended to satisfying the clinical demand in diagnosis and treatment of patients with COVID-19 has been developed by the team of Respiratory Endoscopy Centre of Shanghai Chest Hospital. On April 12, the Robotic System has been tested in the tracheobronchial tree model, doctors completed all the bronchoscopy-related operation actions by controlling the Robotic System via the remote control handle, such as entering the glottis to reach the bronchi of each sub segment, guiding tracheal intubation and monitoring tracheotomy, bronchoscopic aspiration, BAL and collection of BALF [Figure 2a]. After being experimented in animal model [Figure 2b], Robotic System has been successfully applied in a male patient suspect of pulmonary infection [Figure 2c and d], on April 24. The operator performed the bronchoscopy and BAL by Robotic System alone without anybody getting in touch with the patient during the operation process, which significantly reduced the number of participants and the risk of exposure to viral aerosol.

Virtual bronchoscopic navigation and electromagnetic navigational bronchoscopy may be applied to guide Robotic System to the targeted lesions quickly. Bronchoscopy operated by remote control could satisfy the diagnostic and therapeutic needs of patients with COVID-19 and protect the operator from infectious environment by spatial isolation.

Remote controlled manipulators to complete operations across distance boundaries may be the



Figure 2. Research of Robotic system of bronchoscope developed for COVID-19 patients. (a) Robotic system in tracheobronchial tree model. (b) Robotic system in animal model. (c) Robotic system in patient. (d) Computed tomography of the patient

focus of clinical researches in future. Artificial intelligence may contribute to the development of bronchoscopy for patients with COVID-19. With the development of remote control techniques and artificial intelligence in bronchoscope, more efficient technologies will be employed in patients with SARS-CoV-2 infection, and less nosocomial infection will be expected.

SUMMARY AND FUTURE DIRECTIONS

Bronchoscopy is an effective diagnostic technique but not be recommended as a routine sampling method for testing SARS-CoV-2 because of higher potential virus-aerosol transmission of the bronchoscopy procedures. Bronchoscopy could be employed prudently in certain specific or urgent situations, with careful evaluation of the benefits and risks. Full attentions should be paid on multiple factors (obtaining location, quality, handling and processing of bronchoscopy specimens, as well as the accuracy of test methods) that may impact the diagnostic yield of bronchoscopy for testing SARS-CoV-2. Value of bronchoscopy for airway management in critical patients with COVID-19 should not be underestimated. Procedures of the bronchoscopy (bronchoscope types, lavage volume, etc.), analgesia and mechanical ventilation, protective precaution strategies are important to control the bronchoscopy-related nosocomial infection of SARS-CoV-2. Research advances in the remote controlled operations and artificial intelligence may provide the efficient coping strategies for COVID-19 in future.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for

his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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