

## Guidelines

# Conventional flexible bronchoscopy during the COVID pandemic: A consensus statement from the Indian Association for Bronchology

### ABSTRACT

During the times of the ongoing COVID pandemic, aerosol-generating procedures such as bronchoscopy have the potential of transmission of severe acute respiratory syndrome coronavirus 2 to the healthcare workers. The decision to perform bronchoscopy during the COVID pandemic should be taken judiciously. Over the years, the indications for bronchoscopy in the clinical practice have expanded. Experts at the Indian Association for Bronchology perceived the need to develop a concise statement that would assist a bronchoscopist in performing bronchoscopy during the COVID pandemic safely. The current Indian Association for Bronchology Consensus Statement provides specific guidelines including triaging, indications, bronchoscopy area, use of personal protective equipment, patient preparation, sedation and anesthesia, patient monitoring, bronchoscopy technique, sample collection and handling, bronchoscope disinfection, and environmental disinfection concerning the coronavirus disease-2019 situation. The suggestions provided herewith should be adopted in addition to the national bronchoscopy guidelines that were published recently. This statement summarizes the essential aspects to be considered for the performance of bronchoscopy in COVID pandemic, to ensure safety for both for patients and healthcare personnel.

**KEY WORDS:** Bronchoscopy, coronavirus disease-2019, severe acute respiratory syndrome coronavirus 2

**Address for correspondence:** Dr. Amita Nene, Department of Respiratory Medicine, Bombay Hospital Institute of Medical Sciences, 12, New Marine Lines, Mumbai - 400 020, Maharashtra, India. E-mail: [amitadoshi@hotmail.com](mailto:amitadoshi@hotmail.com)

**Submitted:** 25-Oct-2020

**Revised:** 31-Dec-2020

**Accepted:** 09-Jan-2021

**Published:** 06-Mar-2021

### SUMMARY OF FLEXIBLE BRONCHOSCOPY IN COVID PANDEMIC: INDIAN CONSENSUS STATEMENT

During the current coronavirus disease-2019 (COVID-19) pandemic, there is a need to strike a balance between providing medical care to those in need while limiting the exposure to and spread of the disease among other patients and healthcare workers. Due to high viral load in the airways of COVID-19 patients, including asymptomatic individuals, aerosol-generating procedures are best avoided wherever possible, to reduce the potential of transmission to the healthcare workers. There is a high viral load in the airways of COVID-19 patients, substantially increasing the risk to healthcare personnel. Even asymptomatic patients

may have a high viral load in the airways. The decision to perform bronchoscopy in the current context of the COVID-19 pandemic therefore should be made judiciously, reserving itself for situations where it is life-saving or likely to result in significant change in the medical management of the patient. The Indian Association for Bronchology has developed this consensus statement to provide specific guidelines concerning COVID-19 situation, which should be adopted in addition to the national bronchoscopy guidelines that were published recently. The objective of the current consensus statement is to summarize the essential aspects

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** [WKHLRPMedknow\\_reprints@wolterskluwer.com](mailto:WKHLRPMedknow_reprints@wolterskluwer.com)

**How to cite this article:** Chhajed PN, Nene A, Abhyankar N, Akkaraju J, Agarwal R, Arora S, *et al.* Conventional flexible bronchoscopy during the COVID pandemic: A consensus statement from the Indian Association for Bronchology. *Lung India* 2021;38:S105-15.

#### Access this article online

##### Quick Response Code:



##### Website:

[www.lungindia.com](http://www.lungindia.com)

##### DOI:

10.4103/lungindia.lungindia\_953\_20

for the safe conduct of bronchoscopy, both for patients and healthcare personnel in a COVID-19 pandemic scenario.

### Executive summary

1. Patients being considered for bronchoscopy can be triaged as COVID positive, COVID high suspect, and COVID low suspect
2. Indications for bronchoscopy can be divided into urgent bronchoscopy, semi-elective bronchoscopy, and elective bronchoscopy
3. Scheduling of the bronchoscopy will depend on whether the patient is COVID positive, COVID high suspect, or COVID low suspect (based on the patient symptoms, results of the RT-PCR or other standard diagnostic tests, and high-resolution computed tomography chest findings) and based on the urgency of the procedure
4. The following options for the bronchoscopy area are preferred (descending order from ideal to acceptable)
  - a. The ideal option is negative pressure room with at least 12 air exchanges per hour
  - b. Room with at least 12 air exchanges per hour. Decontamination of the room is recommended for at least 20 min after the previous patient exits
  - c. Room with a minimum of 6 air exchanges per hour (1 renewal/10 min). The room decontamination is recommended for at least 60 min after the patient leaves
  - d. Natural ventilation with airflow of at least 160 L/s/patient (hourly average ventilation rate).

Additional requirements of the bronchoscopy area are provided in detail in the main text.

5. It is recommended that in suspected or confirmed COVID-19 patients, the procedure should be performed by the most experienced operator and the additional staffing should be kept to a minimum as per the requirement of the procedure
6. The appropriate use of personal protective equipment (PPE) by doctors and the entire bronchoscopy team is mandatory in the current pandemic. Personnel who perform the cleaning and processing of the bronchoscope will use the same PPE as the rest of the bronchoscopy team
7. Measures to be taken during patient preparation to minimize the risk of infection transmission:
  - a. Prebronchoscopy nebulization with lidocaine should be avoided as they have a high tendency of aerosol production
  - b. Prebronchoscopy nebulization with bronchodilators using nebulizers should be avoided to prevent aerosol production
  - c. In case inhaled bronchodilators need to be administered, a pressurized meter dose inhaler with a spacer device is preferable
  - d. Preprocedure medications including dextromethorphan and codeine may improve the tolerance to the procedure, reduce cough, and

produce less expectoration postprocedure, and one of these may therefore be administered especially if bronchoscopy is being done without deep sedation or general anesthesia

- e. The patient should be made to wear a three-ply orofacial mask all through
  - f. If there are patients with other infectious diseases planned for bronchoscopy on the same day as the COVID patients, the COVID cohort procedures should be planned last to avoid fomite transmission.
8. Sedation and anesthesia
    - a. Since optimal cough suppression is mandatory during the COVID pandemic, every patient undergoing bronchoscopy should preferably receive sedation with midazolam and fentanyl or any other opioid to minimize the risk of infection transmission to the bronchoscopy team
    - b. In COVID low-suspect patients, sedation should be mild to moderate to reduce cough and improve patient tolerance
    - c. In COVID-positive or COVID high-suspect patients, deep sedation should be used to suppress cough and minimize aerosol generation
    - d. Flexible bronchoscopy through an established airway carries less risk of aerosol production than bronchoscopy in a spontaneously breathing patient, and it should therefore be preferred in COVID-positive or COVID high-suspect patients. The airway can be established using an endotracheal tube or using a second-generation laryngeal mask airway (LMA)
    - e. However, LMA does not cause complete sealing of the airway like an endotracheal tube does, and therefore, endotracheal tubes are less aerosol generating than LMAs
    - f. Paralytics may be especially useful in case of an intubated patient to minimize the risk of infection transmission. The aim has been to bring down the Richmond agitation sedation scale to less than or equal to 4.
  9. Monitoring should include pulse oximetry, respiratory rate, and blood pressure monitoring. Electrocardiography monitoring if possible should be done in all patients
  10. The choice of using a reusable bronchoscope or a disposable bronchoscope should be based on local factors such as availability, facility for disinfection, and logistics
  11. Techniques of bronchoscopy  
Practicing the following while performing the flexible bronchoscopy will reduce aerosol generation and will minimize the chances of infection transmission to the bronchoscopy team
    - a. Transnasal approach is preferred over transoral approach<sup>[1,2]</sup>
    - b. A surgical mask should be put on the patient while performing bronchoscopy to minimize the emission

- of aerosols
  - c. The surgical mask should be slotted to permit transmask–transnasal (and less preferably transoral) flexible bronchoscopy
  - d. Use of video bronchoscope is preferred and direct vision bronchoscopy should be avoided
  - e. The operator should be positioned at the head end of the patient, keeping the maximum possible distance from the patient
  - f. Adequate sedation should be used to minimize coughing
  - g. To minimize the droplets produced by the patient's cough, a suction catheter can be used proactively during the bronchoscopy to aspirate secretions from the patient's mouth as needed
  - h. Length of the procedure and number of insertion and withdrawal of scope should be kept to the minimum
  - i. Postprocedure, the patient should be allowed to recover in the same area where the bronchoscopy is performed and not in the recovery room.
12. Measures to be followed for bronchoscopy in patients on noninvasive ventilation and mechanical ventilation to reduce infection transmission are given in the text and should be referred to
  13. If bronchoscopy is being performed for COVID-19 sample collection, a minimum of 2–3 ml of specimen should be collected into a sterile, leak proof, dry container
  14. Once a specimen is obtained, the container should not be re-opened to separate samples. If more than one specimen is needed, then collect a sample in a separate container. Clinical samples need to be sent to the designated laboratory by following standard triple packaging
  15. It is prudent to clamp the suction tubing or turning off suction after the sample has been obtained before disconnecting the sample from the device
  16. In patients with a non-COVID-19 diagnosis, samples to be taken as per the standard guidelines for bronchoalveolar lavage, endobronchial biopsy, transbronchial lung biopsy, and transbronchial needle aspiration
  17. If the bronchoscopy is done in the intensive care unit for a COVID–positive or COVID high-suspect patient, the contaminated bronchoscope must always be transported in a double closed bag
  18. The reusable bronchoscopes must be reprocessed strictly following the high-level disinfection and sterilization standards, with particular care in manual cleaning before disinfection–sterilization. Leak test is mandatory after every bronchoscopy. As far as possible, disposable accessories should be used. Reusable accessories are cleaned in the same standard way
  19. The bronchoscopy suite should be cleaned frequently. The floor should be mopped with a solution containing 1% sodium hypochlorite.

## INTRODUCTION

Coronavirus disease-2019 (COVID-19) is a highly infectious disease with primarily respiratory manifestations caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). As the COVID-19 pandemic ravages the world, there is a need to strike a balance between providing medical care to those in need while limiting the exposure to and spread of the disease among other patients and healthcare workers. As a general convention, it is advisable to avoid aerosol-generating procedures wherever possible, to reduce the potential of transmission to the healthcare workers.

Although bronchoscopy is an important tool for the diagnosis and treatment of various conditions, it is also a high aerosol-generating procedure. Therefore, the decision to perform bronchoscopy in the current context of the COVID-19 pandemic should be made judiciously, reserving the procedure for situations where it is life-saving or will result in significant change in the medical management of the patient.

It is important to note that there is a high viral load in the airways of COVID-19 patients, thus substantially increasing the risk to health care personnel. Even asymptomatic patients may have a high viral load in the airways.<sup>[3]</sup> The tests for detecting SARS-CoV-2 are variable with a sensitivity ranging from 30% to 73% depending on whether an oropharyngeal swab (sensitivity 32%–60%) or nasopharyngeal swab (sensitivity 63%–73%) is used.<sup>[4,5]</sup> Furthermore, asymptomatic patients can also shed the virus.<sup>[6]</sup> To reduce the risk of exposure to healthcare workers, universal precautions should always be adopted while performing a bronchoscopy.

In view of the above facts and taking into account the growing number of reported COVID-19 cases among healthcare workers, the Indian Association for Bronchology has developed this consensus statement to provide specific guidelines with regard to COVID-19 situation, which should be adopted in addition to the national bronchoscopy guidelines that were published recently.<sup>[7]</sup> The objective of the current consensus statement is to summarize the important aspects for safe conduct of bronchoscopy, both for patients and healthcare personnel.

## METHODOLOGY

The Indian Association for Bronchology felt the need of developing a consensus statement to enhance the safety of performing bronchoscopy in the COVID-19 era. Experts in bronchoscopy across India were invited to participate. The points to be included in the consensus statement were discussed and deliberated over phone and e-mails. Upon agreement of these points, nine groups were formed with an expert leading each group. The topics were

distributed among the task force. Each group submitted the expert scripts and the references in the time frame allocated. Upon receipt of the scripts from all groups, a manuscript was drafted. The drafts of the manuscript were circulated in the group for suggestions, editions, and comments. Upon agreement by all the participants, the final version of the manuscript was submitted to the Journal.

## SECTION 1: TRIAGING THE PATIENT

In the current COVID-19 era, performance of bronchoscopy poses a high risk of disease transmission to healthcare workers. All patients planned for bronchoscopy should be screened for symptoms consistent with COVID-19 infection, however, keeping in mind presymptomatic and asymptomatic patients.<sup>[6]</sup> A detailed evaluation for symptoms, travel history, and contact history should be undertaken at the time of scheduling of bronchoscopy procedure, the day before the procedure, and just before the bronchoscopy.<sup>[9]</sup> However, it should be borne in mind that most patients with infection may not present with symptoms even as they are capable of transmitting the disease.

COVID-19 can present with varied clinical features and severity ranging from asymptomatic to severe diseases manifesting as acute respiratory distress syndrome. The most common symptoms at onset include fever, cough, and shortness of breath, and about 80% of infections are mild or asymptomatic (but still contagious).<sup>[10,11]</sup> The other described symptoms of COVID-19 include fatigue, aches, rhinorrhea, sore throat, headache, gastrointestinal symptoms such as diarrhea, vomiting, abdominal pain, anosmia, and loss of taste

Patients being considered for bronchoscopy can be triaged into following categories.<sup>[12,13]</sup>

1. COVID positive: A person with laboratory confirmation of COVID-19 with a positive RT-PCR test report, irrespective of clinical signs and symptoms
2. COVID high suspect: If the patient has any of the typical symptoms of COVID-19 in the last 14 days or if the patient has come in close contact with a suspicious or confirmed COVID-19 case or currently lives in or has visited areas at higher risk of COVID-19 in the last 14 days, or if the patient has high-resolution computed tomography (HRCT) chest findings suggestive of COVID-19, then this patient should be considered as a COVID high suspect despite a negative RT-PCR report<sup>[14]</sup>
3. COVID low suspect: Any patient not fulfilling any of the above-mentioned criteria. However, these patients should be cautiously screened for the other uncommon clinical presentations.

In current times, even in the absence of any features pointing toward COVID-19 suspicion, each and every patient undergoing a bronchoscopy should be assumed to be a COVID suspect and universal precautions should always be taken while performing a bronchoscopy.

## SECTION 2: INDICATIONS OF BRONCHOSCOPY AS PER THE URGENCY OF THE PROCEDURE: ELECTIVE, SEMI-ELECTIVE, URGENT

Bronchoscopy is a high aerosol-generating procedure. If an asymptomatic carrier patient undergoes bronchoscopy, there will be a risk of transmission of COVID-19 virus to healthcare personals. Hence, in such scenario, bronchoscopy procedures for elective indications should be deferred as much as possible.

However, there can be situations where bronchoscopy can be a life-saving procedure or it can provide an alternative diagnosis and change the management of patient completely. Hence, for this purpose, indications for bronchoscopy in these COVID pandemic can be divided into three categories.

1. Urgent bronchoscopy
  - a. Significant symptomatic large airway obstruction due to mass lesion or luminal stenosis
  - b. Foreign body aspiration
  - c. Migrated stent
  - d. Massive hemoptysis.

In these situations, bronchoscopy should be done as soon as possible. Massive hemoptysis is an indication for an emergency bronchoscopy; however, if the airway is secured, then bronchial artery embolization may be preferred, especially if the patient is COVID positive or COVID high suspect.<sup>[9]</sup>

2. Semi-elective bronchoscopy  
In these situations, bronchoscopy can be planned within a few days.
  - a. Posttransplant patient or immunocompromised patient presenting with new-onset lung infiltrates
  - b. Suspected lung cancer
  - c. Acute lobar atelectasis
  - d. Suspected pulmonary tuberculosis or drug-resistant tuberculosis where patient cannot bring out sputum or sputum is negative

3. Elective bronchoscopy  
In these situations, bronchoscopy procedures should be done after patient has been classified as COVID low suspect. The following situations may be considered for elective procedures:
  - a. For tissue biopsy in the evaluation of interstitial lung disease
  - b. Evaluation of nonmassive hemoptysis
  - c. Mild tracheobronchial stenosis
  - d. Routine follow-up of patients with airway stent *in situ*
  - e. Routine check bronchoscopy of lung-transplant recipients
  - f. Bronchial thermoplasty
  - g. Bronchoscopic lung volume reduction.

### SECTION 3: SCHEDULING THE BRONCHOSCOPY AND PREPROCEDURE WORKUP

Scheduling of the bronchoscopy will depend on whether the patient is COVID high suspect, COVID low suspect, or COVID positive (based on the patient symptoms, HRCT chest findings, and results of the RT-PCR test) and based on the urgency of the procedure.

#### Scheduling of bronchoscopy in COVID positive or COVID high suspect

1. Bronchoscopy should be avoided for at least 28 days from the onset of first symptom<sup>[15]</sup>
2. However, in those patients who need urgent bronchoscopy or for whom this delay would be detrimental to their prognosis, bronchoscopy may be carried out after explaining to the patient and the relatives about the possible worsening of ventilatory dynamics and hypoxemia and the high-risk nature of the procedure
3. After 28 days, patient should be reassessed for fitness for bronchoscopy. Bronchoscopy should be done only after the patient completely recovers from all the symptoms and the repeat nasopharyngeal and oropharyngeal swab is negative before taking up the patient for bronchoscopy.<sup>[15,16]</sup>

To confirm the diagnosis of COVID, bronchoscopy should be avoided and all other alternative methods (nasopharyngeal along with oropharyngeal swab, and for intubated patients – endotracheal tube aspirate, mini-bronchoalveolar lavage [BAL]) should be used to collect the sample.<sup>[16]</sup>

#### Scheduling of bronchoscopy in COVID low suspect

If the patient's symptoms and HRCT chest are not suggestive of COVID-19 and if the RT-PCR is negative, then can proceed with the bronchoscopy.

#### Microbiology

It is recommended to obtain RT-PCR by both nasopharyngeal and oropharyngeal swab 24–48 h before the procedure.

#### Radiology

HRCT chest findings need to be assessed for possible underlying COVID-19 infection in addition to any other underlying pathology, which is the primary indication for bronchoscopy. If there is any suspicion of CT findings being consistent with COVID-19, even with negative RT-PCR, a second RT-PCR should be done and consider postponement of the procedure by 28 days from the onset of first symptom if this will not be detrimental to the patient prognosis.<sup>[15,17]</sup> The patient should be reassessed after 28 days with the necessary tests and repeat radiology.

#### Laboratory tests

The current bronchoscopy guidelines in India do not

recommend routine hematology tests before bronchoscopy.<sup>[7]</sup> However, COVID-19 patients may have deranged coagulation profile, and so, platelet count, prothrombin time with international normalized ratio, and activated partial thromoplastin time should be checked if the patient needs any bronchoscopic intervention other than a BAL.<sup>[18]</sup>

### SECTION 4: BRONCHOSCOPY AREA AND BRONCHOSCOPY STAFFING

The area where bronchoscopy is performed in COVID-19 times should fulfill the necessary airborne precautions to minimize the potential infectivity to the bronchoscopy team. Negative pressure room and adequate air exchanges/hour are the two factors that will help minimize the transmission of infection during bronchoscopy in this COVID period.<sup>[15]</sup> A negative pressure room avoids droplets and aerosols produced in the procedure from spreading to neighboring areas. Adequate air exchange is the minimum requirement for reducing infectivity to the personnel. The rationale behind air exchanges is to provide dilution and facilitate exhaust of contaminated air.

The following options for the bronchoscopy area are preferred in order of effectivity, from ideal to acceptable.

- a. Ideal option – Negative pressure room with at least 12 air exchanges per hour: Whenever possible, bronchoscopy should be performed in a negative pressure room with at least 12 air exchanges per hour and with controlled flow side
- b. Second option – Room with at least 12 air exchanges per hour: If a negative pressure room is not available, bronchoscopy should be done in a room with at least 12 air exchanges per hour.<sup>[19]</sup> Decontamination of the room is recommended for at least 20 min after the previous patient leaves<sup>[2]</sup>
- c. Third option – Room with a minimum of 6 air exchanges per hour (1 renewal/10 min): Several existing facilities may not have the provision for more than 12 air exchanges per hour. In such situations, a minimum of six total air exchanges per hour are required, and room decontamination is recommended for at least 60 min after the patient leaves.<sup>[2]</sup> If the heat ventilation and air conditioning system are capable of only six exchanges per hour, then the use of additional exhaust fans can increase the effective number of exchanges
- d. Fourth option – Natural ventilation with air flow of at least 160 L/s/patient (hourly average ventilation rate): If a negative pressure room or recommended air exchanges are not possible, bronchoscopy should be done in an adequately ventilated room (which has natural ventilation) with air flow of at least 160 L/s/patient (hourly average ventilation rate).<sup>[20]</sup> This can be achieved with the use of additional measures such as exhaust fans with adequate pretesting and planning. Planning includes aspects such as installing in areas where room air can be exhausted directly to the outdoors through a wall or roof. Sizing and number of fans depend on the target ventilation

planned, which has to be measured and tested before use.

#### Additional requirements of the bronchoscopy area

- a. The door must remain closed at all times
- b. Air should be exhausted to the exterior, far removed from any intake vents
- c. If recirculation to general ventilation is unavoidable, high efficiency particulate air (HEPA) filters must be installed in the exhaust ducts. The filters should be changed/serviced/replaced according to the manufacturer's recommendations by technicians donned in full personal protective equipment (PPE).

#### Where to perform bronchoscopy?

##### *For coronavirus disease-2019–positive patients and high coronavirus disease-2019 suspects*

For these groups of patients, bronchoscopy should be ideally done in the patient's own isolation room, with recommendations as mentioned above.<sup>[1]</sup> This minimizes the chances of contamination of other personnel/spaces in transportation. Shifting to other areas such as the bronchoscopy suite should be done only for technical issues such as immovable equipment such as anesthesia machines and related infrastructure or complex bronchoscopy tools requiring the bronchoscopy suite. In such a situation, a dedicated corridor must be created for transfer to the bronchoscopy suite. It is essential to minimize personnel for both transport and procedure.

##### *For low coronavirus disease-2019 suspects*

Bronchoscopy should be done in the bronchoscopy suite for those patients where COVID-19 suspicion is low. Bronchoscopy room requirements should be as mentioned above.

##### *Intensive care unit bronchoscopies*

In a COVID-19–positive or a high-suspect patient, routine intensive care unit (ICU) bronchoscopies are not recommended, and should be done only if bronchoscopy would offer significant add-on value to patient management and should be done in a negative pressure isolation area. If a negative pressure room is not available, the procedure may be performed in a single ICU cubicle with a minimal number of personnel with proper protective equipment. There should be minimum 12 air exchanges per hour, with air being exhausted to outside, and HEPA filters in the exhaust ducts if air is being recirculated.

#### Bronchoscopy staffing

The optimal number of team members would be determined by the type of bronchoscopic procedure and should be limited to the minimum number of personnel required. It is recommended that in suspected or confirmed COVID-19 patients, the procedure should be performed by the most experienced operator and not by trainees.<sup>[8]</sup> Consideration should be given for older healthcare workers with potential risk factors to abstain from involvement in bronchoscopy of suspected or confirmed COVID-19 cases.

## SECTION 5: PERSONAL PROTECTIVE EQUIPMENT

Bronchoscopy is an aerosol-generating procedure with the highest potential risk of infection to the healthcare personnel.<sup>[21]</sup> Hence, the operator has to take the maximum precautions to prevent transmission of infection to self and the personnel present during the bronchoscopy.

The appropriate use of PPE by doctors is mandatory in the current pandemic. Before donning the PPE, it is advisable to change into hospital scrubs and footwear. The correct way of donning and doffing of PPE should be practiced and disposed the right way to avoid infection transmission. The use of PPE by healthcare personnel has to be done regardless of the COVID-19 test status of the patient in the current pandemic scenario in view of the possibility of false-negative RT-PCR for COVID-19.<sup>[22]</sup> However, if a patient is confirmed COVID-19 positive, additional precautions may be taken over and above the recommended guidelines.

After donning the PPE, another trained healthcare worker should examine the PPE and make sure of no obvious breach before and after the procedure. An entire set of PPE which includes goggles, face-shield, mask (either N-95 Respirator mask or FFP2 mask or FFP3 mask), two pairs of gloves (preferably nitrile gloves), coverall/gowns (with additional plastic aprons inside the gown if the gowns are not water resistant), head cover, and long shoe cover should be worn by the physician, nursing staff, and the technician assisting bronchoscopy of COVID-19 patients.

Personnel who perform the cleaning and processing of the bronchoscope will use the same PPE like the rest of the bronchoscopy team. While performing bronchoscopy in COVID-19–positive or COVID high-suspect patients, the use of a powered air-purifying respirator by the operator is ideal.<sup>[16]</sup>

## SECTION 6: PATIENT PREPARATION, ANESTHESIA, AND SEDATION

#### Measures to be taken during patient preparation to minimize the risk of infection transmission

1. Prebronchoscopy nebulization with lidocaine should be avoided as they have a high tendency of aerosol production
2. Prebronchoscopy nebulization with bronchodilators using nebulizers should be avoided to prevent aerosol production<sup>[21]</sup>
3. In case inhaled bronchodilators need to be administered, these should be done with pressurized meter dose inhaler plus spacer device
4. Preprocedure medications including dextromethorphan (90 mg to be given 60 min before procedure) and codeine (oral 0.4 mg/kg, 60 min before procedure) have been shown to improve the tolerance to procedure, reduce cough, and produce less

expectoration postprocedure, and one of these may be administered, especially if bronchoscopy is being done without deep sedation or general anesthesia<sup>[23-25]</sup>

5. Cricothyroid lidocaine administration is associated with less cough and superior operator-rated procedure satisfaction during bronchoscopy at a lower cumulative lidocaine dose<sup>[26]</sup>
6. Patient should be made to wear a three-ply orofacial mask all through<sup>[21]</sup>
7. If there are patients with other infectious diseases planned for bronchoscopy on the same day as the COVID-19 patients, the COVID cohort should be planned last to avoid fomite transmission.

### Sedation and anesthesia

#### *Anesthesia and sedation in COVID low-suspect patient*

All flexible bronchoscopies should be done under mild-to-moderate sedation according to standard guidelines.<sup>[7]</sup> Midazolam is the preferred sedative owing to its short half-life and rapid onset of action.<sup>[27]</sup> It should be used along with an opioid, like fentanyl, which is short acting and causes sedation, analgesia, and cough suppression.<sup>[7,27]</sup> Since optimal cough suppression is mandatory during the COVID pandemic, every patient undergoing bronchoscopy should preferably receive sedation with midazolam and fentanyl or any other opioid so as to minimize the risk of infection transmission to the bronchoscopy team.<sup>[28]</sup>

#### *Anesthesia and sedation for COVID-positive or COVID high-suspect patients*

Deep sedation would be preferred to suppress cough and minimize aerosol generation.

Flexible bronchoscopy through an established airway carries less risk of aerosol production than bronchoscopy in a spontaneously breathing patient and should therefore be preferred in COVID-positive or COVID high-suspect patients. Airway can be established using an endotracheal tube or by using second-generation laryngeal mask airway (LMA).

Bronchoscopy through an endotracheal tube is ideal as it causes minimal aerosol generation. Endotracheal tubes with inline adapters prevent disconnection from the ventilator and aerosolization.

LMAs are supraglottic airway devices which are used to access and maintain a clear airway during anesthesia and provide unobstructed ventilation, with their ventilation orifices positioned above the glottis. They can be used in a spontaneously breathing patient as also in those on fully controlled ventilation. Cuffed LMAs are better than uncuffed devices to minimize transmission of droplets, and therefore, cuffed second-generation LMAs are preferred.

However, LMAs do not cause complete sealing of the airway like an endotracheal tube does, and therefore, endotracheal tubes are less aerosol generating than LMAs.

Paralytics may be especially useful in case of intubated patient to minimize the risk of infection transmission.<sup>[29]</sup> The aim has been to bring down the Richmond agitation sedation scale to less than or equal to 4.<sup>[29]</sup> Judicious use of short-acting agents should be done to minimize the side effects. The choice should be based on institutional (anesthetist) preference.

### SECTION 7: MONITORING VITAL PARAMETERS

Monitoring vitals during bronchoscopy, i.e., preprocedure, during procedure, after procedure, is the same as would be done during regular bronchoscopy.<sup>[7]</sup> This includes pulse oximetry, respiratory rate, and blood pressure monitoring. Electrocardiography monitoring if possible should be done in all patients.

### SECTION 8: TYPES OF BRONCHOSCOPES AND TECHNIQUE OF BRONCHOSCOPY

Two types of bronchoscopes can be used: the single-use disposable bronchoscopes (2 and 2.8 mm channel size) or the standard reusable bronchoscopes.

#### *Advantages of single-use bronchoscopes*

1. These would be of help where staff are absent or there is out-of-hour bronchoscopy as there is no requirement to prepare or clean the bronchoscope
2. These are easily portable due to the smaller size of the scope and small portable screen. Therefore, there is reduced requirement of staff during its transport
3. There is no risk of cross-contamination and fomite infection transmission

However, not every facility has access to this equipment, and thus, local resources need to be considered with their use.

#### *Advantages of traditional reusable bronchoscopes*

The traditional bronchoscope has its own advantages including:

1. Operator familiarity
2. Improved vision (including high definition on some systems).

However, from a cross-contamination standpoint, assuming well-controlled reprocessing and an undamaged scope, it is unclear if a single-use bronchoscope truly offers any advantages over a standard flexible bronchoscope in the setting of a suspected or confirmed patient with COVID-19 infection.

The choice of using a reusable bronchoscope or a disposable bronchoscope should be based on local factors such as availability, facility for disinfection, and logistics.

#### *Technique of bronchoscopy*

Practicing the following while performing the flexible

bronchoscopy will reduce aerosol generation and will minimize the chances of infection transmission to the bronchoscopy team.

1. Transnasal approach is preferred over transoral approach<sup>[1,2]</sup>
2. A surgical mask should be put on the patient while performing bronchoscopy to minimize the emission of aerosols
3. The surgical mask should be slotted to permit transmask–transnasal (and less preferably transoral) flexible bronchoscopy<sup>[21]</sup>
4. Bronchoscopy should be carried out by the most experienced members of the team
5. Use of video bronchoscope is preferred and direct vision bronchoscopy should be avoided
6. The operator should be positioned at the head end of the patient, keeping the maximum possible distance from the patient
7. Adequate sedation should be used to minimize coughing
8. To minimize the droplets produced by the patient's cough, a suction catheter can be used proactively during the bronchoscopy to aspirate secretions from the patient's mouth as needed
9. Length of the procedure and number of insertion and withdrawal of scope should be kept to the minimum
10. Postprocedure, the patient should be allowed to recover in the same area where the bronchoscopy is performed and not in the recovery room.

#### Measures to be followed for bronchoscopy in patients on noninvasive ventilation to reduce infection transmission

1. Orofacial masks with a specific opening for the bronchoscope should be used
2. Use closed circuit systems and high-performance fans
3. HEPA filters should be used in between facemasks and the noninvasive ventilatory circuit.

#### Bronchoscopy in mechanically ventilated patients

1. The bronchoscope should be used in closed circuit through an extension valve with inlet valve for the bronchoscope (tee connection)
2. A HEPA filter should be placed in between the endotracheal tube and the ventilator circuit
3. During bronchoscopy, active suctioning placed very close to the endotracheal tube swivel connector during insertion and removal of the bronchoscope may remove viral particles and therefore potentially decrease transmission risk by aerosolization. This process may also be replicated during connector exchanges<sup>[9]</sup>
4. Consideration should be given to suspending ventilation during insertion and removal of the bronchoscope
5. As closed endotracheal suctioning is commonly used in invasive mechanically ventilated patients with COVID-19, the suction tube should also be removed as it may obstruct the bronchoscope. Since ventilation is suspended when removing the suction catheter, two staff

members should work together to contain any aerosol dispersion

6. If patient has a tracheostomy, then, during bronchoscopy, it should be a cuffed tracheostomy tube.

#### SECTION 9: BRONCHOALVEOLAR LAVAGE COLLECTION

1. If bronchoscopy is being performed for COVID-19 sample collection, a minimum of 2–3 ml of specimen should be collected into a sterile, leak proof, dry container
2. Specimen for the other tests should be collected as per standard procedure
3. Once a specimen is obtained, the container should not be re-opened to separate samples. If more than one specimen is needed, then collect a sample in a separate container
4. In a COVID-19–positive or high-suspect patient, it is prudent to clamp the suction tubing or turning off suction after the sample has been obtained before disconnecting the sample from the device.

#### Sample handling

1. Level 3 PPE needs to be used and all biosafety precautions should be followed so as to protect individuals and the environment
2. In cases of suspected or confirmed COVID-19 infection, we recommend proactive communication with the receiving laboratory and labeling the sample as suspected or confirmed COVID-19
3. Label preparation should be done before the procedure
4. Clinical samples need to be sent to the designated laboratory by following standard triple packaging.<sup>[30]</sup>

#### Procedure to transport bronchoscope back to the bronchoscopy room when the bronchoscopy is done in the intensive care unit or in the COVID-positive patient's room or to bronchoscopy cleaning area if it is outside the bronchoscopy room<sup>[1]</sup>

1. The contaminated bronchoscope must always be transported in a double closed bag
2. The personnel who have used it and who are wearing a double glove introduce it in the first bag without touching the outside of it. The first pair of gloves is then removed and close the bag
3. Now, insert it into the second bag without touching the outside of it.

Other gloved person closes the second bag and transports the bronchoscope to the bronchoscopy room.

#### SECTION 10: DISINFECTION, DISPOSAL, SANITATION IN CORONAVIRUS DISEASE-2019–POSITIVE AND HIGH-SUSPECT PATIENTS

The single-use disposable bronchoscopes may be used if available in which case no cleaning and disinfection of the scope is required and they can be disposed off after use. If



disposable bronchoscopes are not available, the reusable bronchoscopes must be reprocessed strictly following the high-level disinfection and sterilization standards, with particular care in manual cleaning before disinfection-sterilization.

Following additional disinfection measures are recommended for reusable bronchoscopes, which are to be carried out in addition to the standard bronchoscopy disinfection guidelines.<sup>[7]</sup>

1. Ideally, disinfection and reprocessing of the bronchoscope should be performed in a room separate from the operating room ensuring that there are at least 12 air exchanges per hour. If such a facility is not available, simple exhaust fans can be employed to ascertain the requisite air exchanges<sup>[19]</sup>
2. The personnel involved in reprocessing must be donned in a complete level 3 PPE, same as that is worn by the bronchoscopy team
3. All bronchoscopes should be carefully inspected after use and must undergo a leak test
4. Leak test is mandatory after every bronchoscopy. Any scope that fails the leak test should immediately be removed from service, as it is not possible to fully sterilize this scope and can transmit infection to the next patient. Only after the leak test is completed and passed, should enzymatic cleaner be used on the scope
5. The bronchoscope valves and plugs must ideally be discarded after every bronchoscopy, due to the difficulty in cleaning and in drying them
6. The disposable brushes used to clean the working channel and the suction channel of the bronchoscope should ideally be discarded after every use. The reusable brushes should be mechanically cleaned and sterilized.

#### Disinfection and disposal of the accessories

As far as possible, disposable accessories should be used. Reusable accessories are cleaned in the same standard way.

#### Treatment of disposable accessories before disposal

Disposable accessories should be initially submerged in 1% sodium hypochlorite solution for at least 30 min. After treatment with the hypochlorite solution, the accessories should be packed in double bags and sent for routine biomedical waste disposal.<sup>[31]</sup> The sharp objects such as forceps and needles should be inundated in a nonpermeable box containing the hypochlorite solution. Such treatment is done to prevent any contamination due to an accidental breach during the transport of the used items. All the disinfected articles should then be sent for disposal as per the hospital protocol for non-COVID items

#### DISINFECTION OF TROLLEYS, MONITORS, AND PATIENT BEDS

Surfaces should be disinfected by wiping clean with either 1% sodium hypochlorite solution or an alcohol-based

surface cleaning solution containing 70% isopropyl alcohol or 70% ethyl alcohol using an absorbent cloth. Alcohol should be used to clean metal surfaces (e.g., trolleys) where the use of bleach is not suitable. All the mopping material should be discarded in garbage bags and incinerated.

#### BRONCHOSCOPY SUITE SANITATION

1. The bronchoscopy suite should be cleaned frequently. The floor should be mopped with a solution containing 1% sodium hypochlorite. The mop should either be a single-time use disposable towel or should undergo daily laundry cleaning (after immersion in 1% sodium hypochlorite). In fact, cleaning of the contaminated area using the same mop can be a source of spread of infection in a healthcare facility<sup>[32]</sup>
2. In case of a spill of a potentially infected fluid, 1% sodium hypochlorite solution should be poured before soaking up the fluid with absorbent cloth. The absorbent cloth must then be incinerated
3. In bronchoscopy rooms, which have at least 12 air exchanges per hour, the bronchoscopy room will have to be kept closed for at least 20 min after the patient leaves the bronchoscopy room
4. Those rooms that have six air exchanges per hour, the bronchoscopy room will have to be kept closed for at least 1 h after the patient leaves the bronchoscopy room

#### Disposal of personal protective equipment

The PPE should be discarded in an appropriate bag (yellow) and should be processed as biomedical waste.

#### CONCLUSION

These guidelines have been specifically created for bronchoscopists performing bronchoscopy in COVID-19-positive or COVID-19 suspect patients for the safety of all healthcare workers and to prevent transmission of infection. Since bronchoscopy is an aerosol-generating procedure, an improperly performed bronchoscopy may aid in transmission of COVID-19 infection through droplets. Due consideration must be given to the indication, preparation, and planning for the procedure. The bronchoscopy itself must be carried out with all due precautions. Postprocedure disposal should be carried out of all infected material including PPE and disinfection of possible contamination of the bronchoscopy suite/ICU/equipment for a safe outcome of this procedure.

#### Financial support and sponsorship

Nil.

#### Conflicts of interest

There are no conflicts of interest.

**Prashant N. Chhajed<sup>1</sup>, Amita Nene<sup>2</sup>, Nitin Abhyankar<sup>3</sup>, Jayachandra Akkaraju<sup>4</sup>, Ritesh Agarwal<sup>5</sup>, Surinder Arora<sup>6</sup>, Rajani Bhat<sup>7</sup>, Rakesh Chawla<sup>8</sup>, DJ Christopher<sup>9</sup>, Sushmita Roy Chowdhary<sup>10</sup>, Raja Dhar<sup>11</sup>, Sahajal Dhooria<sup>5</sup>, Rajiv Goyal<sup>12</sup>, Richa Gupta<sup>9</sup>, Prince James<sup>9</sup>, Parvaiz A Koul<sup>13</sup>, A K Abdul Khader<sup>14</sup>, Karan Madan<sup>15</sup>, Vikas Marwah<sup>16</sup>, Ravindra Mehta<sup>17</sup>, Anant Mohan<sup>15</sup>, Vivek Nangia<sup>18</sup>, Dharmesh Patel<sup>19</sup>, V R Pattabhiraman<sup>20</sup>, Inderpaul Singh Sehgal<sup>5</sup>, Sheetu Singh<sup>21</sup>, Arjun Srinivasan<sup>20</sup>, Rajesh Swarnakar<sup>22</sup>, Shyamsunder Tampi<sup>2</sup>**

<sup>1</sup>Lung Care and Sleep Centre; Institute of Pulmonology, Medical Research and Development, Mumbai, Maharashtra, India,

<sup>2</sup>Department of Respiratory Medicine, Bombay Hospital Institute of Medical Sciences, Mumbai, Maharashtra, India, <sup>3</sup>Department of Respiratory Medicine, Poona Hospital, Pune, Maharashtra, India, <sup>4</sup>Department of Respiratory Medicine, Virinchi Hospital, Hyderabad, Telangana, India, <sup>5</sup>Department of Pulmonary Medicine, Postgraduate Institute of Medical Education and Research, Chandigarh, India, <sup>6</sup>Batra Hospital and Medical Centre, New Delhi, India, <sup>7</sup>Board of Doctors, New Delhi, India, <sup>8</sup>Department of Respiratory Medicine, Jaipur Golden Hospital, New Delhi, India, <sup>9</sup>Department of Pulmonary Medicine, Christian Medical College, Vellore, Tamil Nadu, India, <sup>10</sup>Department of Respiratory Medicine, Apollo Gleaneagles Hospital, Kolkata, West Bengal, India, <sup>11</sup>Department of Pulmonary Medicine, Fortis Hospital, Kolkata, West Bengal, India, <sup>12</sup>Department of Respiratory Medicine, Jaipur Golden Hospital and Rajiv Gandhi Cancer Hospital, New Delhi, India, <sup>13</sup>Sher-i- Kashmir Institute of Medical Sciences, Srinagar, Jammu and Kashmir, India, <sup>14</sup>Department of Pulmonary Medicine, KMCT Medical College, Kozhikode, Kerala, India, <sup>15</sup>Department of Pulmonary Medicine, All India Institute of Medical Sciences, New Delhi, India, <sup>16</sup>Department of Pulmonary, Critical Care and Sleep Medicine, Army Institute of Cardiothoracic Sciences (AICTS), Pune, Maharashtra, India, <sup>17</sup>Department of Respiratory Medicine, Apollo Hospitals, Bengaluru, Karnataka, India, <sup>18</sup>Institute of Respiratory, Critical Care and Sleep Medicine, Max Hospital, Saket Complex, New Delhi, India, <sup>19</sup>City Clinic and Bhailal Amin General Hospital, Vadodara, Gujarat, India, <sup>20</sup>Department of Respiratory Medicine, Royal Care Hospital, Coimbatore, Tamil Nadu, India, <sup>21</sup>Department of Chest and Tuberculosis, Institute of Respiratory Disease, Jaipur, Rajasthan, India, <sup>22</sup>Department of Respiratory Medicine, Getwell Hospital and Research Institute, Nagpur, Maharashtra, India

## REFERENCES

- Cordovilla R, Álvarez S, Llanos L, Nuñez Ares A, Cases Viedma E, Díaz-Pérez D, et al. SEPAR and AEER consensus recommendations on the use of bronchoscopy and airway sampling in patients with suspected or confirmed COVID-19 infection. *Arch Bronconeumol* 2020;56 Suppl 2:19-26.
- Bugalho AF, Bastos HN, Mota L, Rodrigues LV, Boléo-Tomé JV, Campainha S. Company Position Document. Portuguese Pneumology for Broncoscopias During the Survey of COVID-19. Available from: <https://www.ersnet.org/covid-19/covid-19-guidelines-and-recommendations-directory/>.
- Zou L, Ruan F, Huang M, Liang L, Huang H, Hong Z, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N Engl J Med* 2020;382:1177-9.
- Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, et al. Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA* 2020;323:1843-4.
- Yang Y, Yang M, Yuan J, Wang F, Wang Z, Li J, et al. Comparative

- sensitivity of different respiratory specimen types for molecular diagnosis and monitoring of SARS-CoV-2 Shedding. *Innovation (N Y)* 2020;1:100061. doi: 10.1016/j.xinn.2020.100061.
- Bai Y, Yao L, Wei T, Tian F, Jin DY, Chen L, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA* 2020;323:1406-7.
- Mohan A, Madan K, Hadda V, Tiwari P, Mittal S, Guleria R, et al. Guidelines for diagnostic flexible bronchoscopy in adults: Joint Indian Chest Society/National College of chest physicians (I)/Indian association for bronchology recommendations. *Lung India* 2019;36:S37-S89.
- Irish Thoracic Society. Statement on Bronchoscopy and SARS COVID-19; 2020. Available from: <https://Irishthoracicsociety.com/V.1.1.1>. [Last accessed on 2020 Mar 27].
- Pritchett MA, Oberg CL, Belanger A, De Cardenas J, Cheng G, Nacheli GC, et al. Society for Advanced Bronchoscopy Consensus Statement and Guidelines for bronchoscopy and airway management amid the COVID-19 pandemic. *J Thorac Dis* 2020;12:1781-98.
- Centre for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19). Available from: <https://www.cdc.gov>.
- World Health Organization. Coronavirus Disease 2019 (COVID-19): Situation Report, 59. World Health Organization; 2020. Available from: <https://apps.who.int/iris/handle/10665/331597>.
- National Centre for Disease Control, Directorate General of Health Services, MoHFW, New Delhi. The Updated Case Definitions and Contact-Categorisation. Available from: <https://ncdc.gov.in>.
- World Health Organization. Coronavirus Disease 2019 (COVID-19): Situation Report, 73. World Health Organization; 2020. Available from: <https://apps.who.int/iris/handle/10665/331686>.
- World Health Organization. Coronavirus Disease 2019 (COVID-19): Situation Report, 90. World Health Organization; 2020. Available from: <https://apps.who.int/iris/handle/10665/331859>.
- Baldwin DL, Rintoul WS, Navani R, Fuller N, Woolhouse L, Booton IE, et al. Recommendations for Day Case Bronchoscopy Services during the COVID-19 Pandemic. Available from: <https://www.brit-thoracic.org.uk>. [Last accessed on 2020 Mar 25].
- Wahidi MM, Lamb C, Murgu S, Musani A, Shojaee S, Sachdeva A, et al. American Association for Bronchology and Interventional Pulmonology (AABIP) Statement on the use of bronchoscopy and respiratory specimen collection in patients with suspected or confirmed COVID-19 infection. *J Bronchology Interv Pulmonol* 2020;27:e52-4.
- Long C, Xu H, Shen Q, Zhang X, Fan B, Wang C, et al. Diagnosis of the Coronavirus disease (COVID-19): rRT-PCR or CT? *Eur J Radiol* 2020;126:108961.
- Tang N, Li D, Wang X, Sun Z. Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. *J Thromb Haemost* 2020;18:844-7.
- CDC Guidelines for Environmental Infection Control in Health-Care Facilities; 2003. Available from: <https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html>. [Last accessed on 2020 Apr 16].
- World Health Organization. Infection Prevention and Control during Health Care When Novel Coronavirus (nCoV) Infection is Suspected. Interim guidance; March 19, 2020. World Health Organization; 2020.
- Lentz RJ, Colt H. Summarizing societal guidelines regarding bronchoscopy during the COVID-19 pandemic. *Respirology* 2020;25:574-7.
- Li Y, Yao L, Li J, Chen L, Song Y, Cai Z, et al. Stability issues of RT-PCR testing of SARS-CoV-2 for hospitalized patients clinically diagnosed with COVID-19. *J Med Virol* 2020;92:903-8.
- Schwarz Y, Greif J, Lurie O, Tarrasch R, Weinbroum AA. Dextromethorphan premedication reduces midazolam requirement: Objective and subjective parameters in peribronchoscopy. *Respiration* 2007;74:314-9.
- Tsunezuka Y, Sato H, Tsukioka T, Nakamura Y, Watanabe Y. The role of codeine phosphate premedication in fibre-optic bronchoscopy under insufficient local anaesthesia and midazolam sedation. *Respir Med* 1999;93:413-5.
- Amini S, Peiman S, Khatuni M, Ghalamkari M, Rahimi B. The effect of dextromethorphan premedication on cough and patient tolerance during flexible bronchoscopy: A Randomized, double-blind, placebo-controlled trial. *J Bronchology Interv Pulmonol* 2017;24:263-7.
- Madan K, Mittal S, Gupta N, Biswal SK, Tiwari P, Hadda V, et al. The Cricothyroid versus spray-as-you-go method for topical anesthesia during flexible bronchoscopy: The CRISP randomized clinical trial. *Respiration* 2019;98:440-6.
- Chhajed PN, Wallner J, Stolz D, Baty F, Strobel W, Brutsche MH, et al.

Chhajed, Nene, *et al.*: Bronchoscopy during COVID pandemic

- Sedative drug requirements during flexible bronchoscopy. *Respiration* 2005;72:617-21.
28. Stolz D, Chhajed PN, Leuppi JD, Brutsche M, Pflimlin E, Tamm M. Cough suppression during flexible bronchoscopy using combined sedation with midazolam and hydrocodone: A randomised, double blind, placebo controlled trial. *Thorax* 2004;59:773-6.
  29. He M, Xiong J, Huang S, Bian Y, Yan P, Redding SR. Airborne precautions recommended in Wuhan, China for bedside fiberoptic bronchoscopy examination of patients with COVID-19. *J Infect* 2020;81:e75-e77.
  30. Virology ICfMRaNI. Specimen Collection, Packaging and Transport Guidelines for 2019 Novel Coronavirus (2019-nCoV); 2020.
  31. Central Pollution Control Board Guidelines for Handling, Treatment, and Disposal of Waste Generated during Treatment/Diagnosis/Quarantine of COVID-19 Patients; March 18, 2020. Available from: <https://www.cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/BMW-GUIDELINES-COVID.pdf>. [Last accessed on 2020 Apr 17].
  32. Chemaly RF, Simmons S, Dale C Jr., Ghantaji SS, Rodriguez M, Gubb J, *et al.* The role of the healthcare environment in the spread of multidrug-resistant organisms: Update on current best practices for containment. *Ther Adv Infect Dis* 2014;2:79-90.