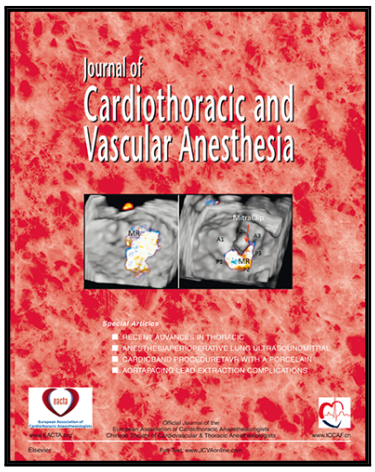
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.



Thoracic Anesthesia of Patients with Suspected or Confirmed 2019 Novel Coronavirus Infection: Preliminary Recommendations for Airway Management by the EACTA Thoracic Subspecialty Committee

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Highlights

- Thoracic anesthesiologists might be involved in the perioperative care of patients suspected to have or diagnosed COVID-19 who might undergo thoracic surgery during the acute or convalescence phases of the disease.
- Caution should be exercised when securing the airway and performing lung separation (if required), through vigilant donning/doffing of personal protection equipment (PPE), planning ahead, team briefing, proper preparations, systematic approach, and debriefing.
- Lung separation / isolation should be individualized using either bronchial blockers or double lumen tubes according to the patient's status and postoperative care plan.
- Optimum PPE donning should be maintained during surgery and anesthesia. One lung ventilation could be challenging in this group of patients.
- The anesthesiologists should discuss the feasibility of extubating the patient following thoracic surgery, and procedures for postoperative care andtransferring the patient to the isolation wards or intensive care unit.

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Running Title: Thoracic Anesthesia for COVID-19 Patients

Abstract:

The novel coronavirus has caused a pandemic around the world. Management of patients with suspected or confirmed coronavirus infection who have to undergo thoracic surgery will be a challenge for the anesthesiologists. infection who have to undergo thoracic surgery will be a challenge for the anesthesiologists. The thoracic subspecialty committee of European Association of Cardiothoracic Anaesthesiology (EACTA) has conducted a survey of opinion in order to create recommendations for the anesthetic approach to these challenging patients.

It should be emphasized that both the management of the infected patient with COVID-19 and the self-protection of the anesthesia team constitute a complicated challenge. The text focuses therefore on both important topics.

Keywords:

Thoracic anesthesia; lung separation; Personal protective equipment; Corona; COVID-19

Background

In December 2019, a novel, ongoing outbreak of pneumonia was reported in Wuhan city, Hubei province, China. A novel coronavirus (CoV) was found to be responsible for the outbreak in patients from Wuhan, now named *severe acute respiratory syndrome coronavirus 2 (*SARS-CoV-2***).*** Though primarily a zoonotic infection, SARS-CoV-2 is now known to spread from person-to-person, in which asymptomatic as well as symptomatic carriers play a role. In a very short time, SARS-CoV-2 has become an international outbreak and WHO has declared it as of 2rd of March 2020 a “pandemic”.

The most common symptoms are dry cough, fever, and shortness of breath leading in about 5% of cases to respiratory failure. Age and co-morbidities are risk factors; older patients and patients with diseases such as hypertension, diabetes mellitus, immunocompromised, cancer, etc, have a higher mortality.

Viral particles entering the lungs via droplets propagated through sneezing, coughing and even talking to the infected are responsible for the spread of the disease. In patients undergoing procedures such as intubation, extubation, airway suctioning or even with using some types of non-invasive ventilation, aerosols (containing droplets having a diameter of < 5µm Ø) may be propagated which more easily reach small airways. Other routes of spread such as direct contact with the infected are also possible.

As of March 25, 2020, there are 428405 confirmed cases and 19273 deaths in 195 countries around the world.

General airway management and ventilation of COVID-19 patients

These patients present with a spectrum of respiratory distress ranging from dyspnoea and hypoxia to acute respiratory distress syndrome (ARDS) and may require respiratory support in different locations such as the emergency room, isolation ward and intensive care units. A significant portion of these patients require early mechanical ventilation involving urgent or emergency tracheal intubation. In addition, with the pandemic nature of the current outbreak, patients with mild or asymptomatic disease may still present for urgent or emergency general or specialised surgery.

Recognizing the unique risks of intubation and mechanical ventilation in these high-risk groups and the high potential of infection risk to healthcare workers, several useful reports, algorithms and society endorsed recommendations have emerged in the recent literature

regarding the *general* airway and anesthesia management of these patients. These societies include SIARRTI (Società Italiana di Anestesia Analgesia Rianimazione e Terapia Intensiva), WFSA (World Federation of Societies of Anaesthesiologists), APSF (Anesthesia Patients Safety Foundation) etc), the United Kingdom Societies (The Faculty of Intensive Care Medicine, Intensive Care Society, Association of Anaesthestists, and Royal College of Anaesthetists), the Consensus Statement of the Australian Societies, The SFAR (Société Française d'Anesthésie et Réanimation), The Canadian Society of Anesthesiologists and the Task Force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists.[1-9] Most of these recommendations are in the context of intensive care management or the surgical setting including emergency surgical cases and those presenting for specific disciplines like Cesarean delivery (in 17 cases).[10]

Thoracic surgery and anesthesia in the COVID-19 era

The novel coronavirus pandemic has radically changed the landscape of normal surgical practice with most elective surgeries being postponed. Lifesaving cancer surgery however remains a clinical priority and there is an increasing need to fully define the optimal oncological management of patients with varying stages of lung cancer, allowing prioritization of which urgent and emergency thoracic procedures should be performed in the current era. Management of general anesthesia, particularly airway management, ventilation and perioperative care of these patients constitutes a further and important challenge for the anesthetist.

The European Association of Cardiothoracic Anaesthesiology (EACTA) Thoracic Anaesthesia Subspecialty group has considered these challenges and developed a preliminary set of expert recommendations regarding the airway management and ventilation of COVID-

19 thoracic patients. Our consensus builds on the previous society recommendations on general airway management principles but expands those recommendations by specifically focusing on unique aspects of thoracic anesthesia.

Methods

The principal methodologies underpinning our recommendations include expert opinions through broad discussions reviewing clinical experience of routine thoracic surgery in similar cases during the Middle East Respiratory Syndrome (MERS-CoV) outbreak and during the current pandemic with suspected COVID-19 patients, literature searching and a limited survey of members of the subcommittee.

Literature search

We searched the literature for direct and indirect evidence on the management of COVID-19, SARS, MERS-CoV, and H1N1 patients. We electronically searched major databases, i.e. MEDLINE and Google, to identify recent consensus recommendations, guidelines, relevant systematic reviews, randomized controlled trials (RCTs), observational studies, and case series. These electronic searches were performed looking for studies published in English from inception to March 23, 2020. To develop recommendations on airway management and lung separation, we used recently published articles and asked the expert panel to identify any novel relevant studies.

"Opinion Survey"

The survey was sent to 28 members of the EACTA Thoracic Network via What's App and Facebook. Twenty-one responses (75%) were received after sending two reminders. The

responses have been evaluated in light of recent publications of different societies and groups (referred to above).

Recommendation Formulation

The group has considered a broad spectrum of issues regarding thoracic anesthesia in COVID-19 patients and decided to focus on overall approaches to general and specific aspects of airway management, preparation for anaesthesia, lung isolation/separation and ventilation.

To arrive at consensus recommendations, we combined the principles outlined in the reviewed publications and our expert opinions. The recommendations take into consideration the balance between benefit and harm, safety concerns, and feasibility in specific environments.

As our goal was to make this preliminary consensus rapidly available to all thoracic teams, we acknowledge limitations of the adopted methodology. Our document should be the basis of future Task Forces to develop a more comprehensive and perhaps multi-society consensus taking into appropriate consideration new evidence uncovered during the COVID-19 epidemic.

Recommendations.

General considerations and principles:

Table 1 summarizes our recommendations regarding general aspects of airway management. They provide a comprehensive framework with major emphasis towards efficient team efforts to achieve successful airway control and establishing controlled ventilation without compromising the high-risk patient whilst providing maximal protection to the health care team. It appears that most of these recommendations are fairly consistent among these

societies considering vigilant infection control and the required organizational tasks and technical conduct of intubation.

We recognize that many of these are relevant to thoracic patients and generally endorse those conclusions with some modifications as follows.

Tracheal intubation in COVID-19 patients for thoracic surgery

- Tracheal intubation in COVID-19 patients for thoracic surgery is a high-risk procedure for the anesthesia team because of the risks of aerosol transmission of the infection during placement of the airway device and check bronchoscopy. It is also a risk for the patients with severe COVID-19 who would not tolerate long periods of apnea or inadequate oxygenation in case of delayed or failed tracheal intubation.
- The procedure should be "S"afe (for staff and patient), "A"ccurate (avoiding unreliable, unfamiliar or repeated techniques) AND "S"wift (timely, without rush and delay). (Mnemonic: SAS).[4]
- As asymptomatic patients may also have the viral infection during the pandemic, and false negative tests cannot be excluded with certainty, it is prudent that the team takes a cautious approach and considers every patient undergoing surgery as potentially positive for infection. These considerations require specific protective measures, sophisticated organization and team practices.
- An elective procedure should be preferred if possible, as emergency intubation may compromise protective procedures and could also increase the patient's risk.
- Ideally, the location of intubation should be an "isolated" negative pressure room with >12 air changes/minute. There are hoewever few operating rooms (OR) with negative pressure facilities which are more commonly available in intensive care units. If a negative pressure OR is not available:

- The level of Personal Protection Equipment (PPE) should be increased (e.g. mask/respirator type and face shield or helmet.

- Alternatively, intubation can be performed in a negative pressure room followed by transfer to the OR, such as in isolated ward or intensive care unit (ICU). The benefits of such an approach however need to be judged against its disadvantages and possible complications.

- In rooms with positive pressure, the room can be put under the least possible positive pressure and the rest of the unit under higher positive pressure, and the doors should be kept closed, so that the high exchange rate of air in operating theatres limits dispersion of aerosols outside the theatre, despite the positive pressure.

- Medical staff involved in tracheal intubation should be limited to those with essential roles. Due to the high risk of infection, we suggest that members of the intubating team should not include practitioners with significant vulnerability such as older age (> 60yrs), immunosuppressed, pregnant or having serious chronic co-morbidities.

  - Inside the room, there must be two attendants in the "red zone": Intubation should be performed by the most experienced physician to minimize delay or related complications; a second doctor should help to administer drugs and monitor the patient be available in case of unanticipated difficulty. The authors want to note that many other societies suggest three attendants (with full donning) in the red zone; however, in this period of the pandemic, this criterion is probably not possible to achieve.

  - There must a "runner" physician available directly outside the room in "yellow zone" with full donned personal protection equipment (PPE), in case of need for help.

- Outside the dedicated OR "white zone", there must be also be an observer to monitor the "donning/doffing" process of the PPE.
- The surgical, anesthesia, nursing and paramedical staff who are not involved with airway management should not enter the operating theatre until after the airway has been secured.

- Several levels of Personal Protection Equipment (PPE) have been defined for different procedures by different societies. Intubation and bronchoscopy are among the "aerosol-generating" procedures and are associated with increased infection risk. During intubation in thoracic anesthesia, it is suggested to work with so-called "Air borne level" precautions, which include the following components of appropriate PPE:
  - Hair covers/hoods.
  - Fitted filtering facepiece (FFP)3 / N95 / FFP2 masks.
  - Goggles or face shield.
  - Long sleeve fluid-resistant gown.
  - Double gloves.
  - Overshoes.
- Maintaining the sequence for donning and doffing PPE (Table 2) is very important to avoid any contagion. This process can be challenging especially for attendants with less experience, and therefore requires thorough training, practice and constant monitoring during the actual procedures by an external observer.

Intubation for thoracic anesthesia:

Preparation:

- Trolley: It is recommended to prepare a dedicated trolley for tracheal intubation of this special group of patients (Table 3 shows the possible content). Disposable devices (e.g. single-use blades, laryngoscopes, video laryngoscopes with remote screens, and flexible bronchoscopes) should be preferred. A closed system for suction should be kept ready. Antifogging material is required. Specific equipment for thoracic surgery (appropriate sizes of double-lumen tubes, bronchial blocker, and fiberoptic bronchoscope) should also be ready and prepared.
- Before intubation, a complete evaluation and optimization of patient's position (45-degree head up, sniffing position), oxygenation and hemodynamic status should be performed using a developed checklist.
- Standard routine monitoring, including continuous waveform capnography should be available before, during and after tracheal intubation.
- The breathing circuit should be checked as normal. The authors suggest that antiviral filters should be attached to the expiratory limb of the circuit.

Preoxygenation:

- Appropriate preoxygenation is crucial as it can prevent / decrease the need for mask ventilation before securing the airway.
- Preoxygenation should be performed using a well-fitting face mask and a Mapleson C ('Waters') or anesthetic circuit, performed 8 breaths during the minute at forced vital capacity, or with a CPAP/PSV of 10 cm H_2O and PEEP of 5 cm H_2O for 3-5 minutes.

- Face mask ventilation should be avoided unless needed. If necessary, a 2- person, low flow, low pressure technique should be used; a 2-person, 2-handed mask ventilation with a VE-grip should be performed to improve seal.

Induction:

- A "rapid sequence induction" should be applied in all patients.
- Ketamine 1.5-2 mh/kg or appropriate doses of propofol and an opioid is recommended for hypnosis and analgesia; rocuronium 1.2 mg/kg or suxamethonium 1.5 mg/kg for neuromuscular blockade.

Intubation:

- Intubation should be performed using VIDEOLARYNGOSCOPY, preferably via a laryngoscope with a and single-use blade if applicable and separate remote screen. The latter would extend the distance between the airway of the patient and the anesthetist to minimize or avoid "airborne spread".
- The pathway for an unanticipated difficult airway in thoracic operation is similar to that of general airway management (Figure 1a):
  - The 1st laryngoscopy should be performed with an endotracheal tube pre-loaded on introducer.
  - If the 1st attempt fails, a re-oxygenation period can be needed, which needs to be performed with a low tidal volume/pressure to avoid leakage of contaminated air.
  - If a 3rd attempt is necessary, an early switch to a second generation- intubatable supraglottic airway device should be considered. Intubation through this device should be performed with a flexible (preferably disposable) endoscope, again with a separate remote screen.

- The ETT cuff or the cuff of the tracheal lumen of the DLT should be inflated to seal the airway before starting ventilation and the depth should be noted and recorded. The cuff pressure should be kept at least 5-10 cmH_2O above the maximum airway pressure using an inflatable manometer. This is to ensure adequacy of cuff seal and minimize the risks for aerosol spread

Double-lumen tube (DLT) or bronchial blocker (BB) (Figure 1b)

- The attending anesthetist should be aware of the indications and the difference between lung separation and isolation. This definition has replaced the historical classification of absolute and relative indications of one-lung ventilation (Table 4).
- In general, 95.2% of the respondents to the survey have reported that they would use a bronchial blocker (BB), and 47.6 % a double-lumen tube (DLT) in patient with, or suspected to have COVID-19, The sum is > 100% as some members advocated the possible use of both devices for different indications (Figure 2).
- The use of BB for all patients is advocated by 52.4%; 33.3% would use BB in already intubated patients, and 9.5% in patients with difficult airway. Conversely, 28.6% would use DLT in all cases, and 19% only in non-intubated cases (Figure 3).

Bronchial blockers

- Lung separation with endotracheal tube (ETT) and BB can be preferred particularly:
  - In already intubated patients (this approach would avoid the risk of aerosolization during tube exchange);
  - In patients with difficult airway (a “difficult” airway for ETT can be even more difficult for DLT);
  - In short procedures;

- In patients in whom the mechanical ventilation will be continued in the postoperative period (to avoid the need for tube exchange at the end of the operation, which can be more difficult because of the edema of the airways and be an additional mechanism of contagion).

– It is suggested to use an ET-tube swivel-connector with a valve. Before opening the valve of the swivel and introducing the bronchoscope, the anesthesia ventilator should be paused. If saturation is critical, preoxygenation can be performed in advance. During bronchoscopy, ventilation may be resumed, but it is important to ensure that the valve of the swivel fits snuggly enough such that there is no leakage. Otherwise bronchoscopy should be performed during apnea. The same procedure should be carried out when the bronchoscope is withdrawn from the tube. Other openings of the airway, e.g. suctioning, should also be performed under apnea.

– If a BB is to be used, the trachea of the patient is intubated with a standard ETT: A 7.5-8.0 mm ID (females) or 8.0-9.0 mm ID (males) ETT with a subglottic suction port should be chosen. It is a general rule to choose the largest possible ETT for intubation in order to allow enough room for the insertion of both the bronchial blocker and the fiberoptic bronchoscope. These ETT's diameters are convenient for this approach. As the confirmation of the position of the tube may be difficult while wearing PPE, the cuff should be passed 1-2 cm below the cords to avoid bronchial placement.

– Tracheal intubation should be confirmed with continuous waveform capnography.

– In cases intubated with ETT and BB, the position of the BB (and the tube) should be confirmed with a disposable flexible bronchoscope or an ETT with an embedded camera.

Double lumen tubes

- Lung separation /isolation with DLT has the general advantages of DLT for one-lung ventilation:
  - Allows better suction
  - Continuous positive airway pressure (CPAP) application is easier
  - Most importantly: anesthetists are more familiar with DLT (which can lead to complications in cases where a BB should be preferred)
- The position of the DLT should be confirmed with a disposable flexible bronchoscope; use of a DLT with an embedded camera can minimize the requirement for a bronchoscope and avoid the need to open the airway.
- Ideally, disposable bronchoscopes are the best option to avoids the need for decontamination after the procedure. If disposable devices are not available, reusable bronchoscopes can also be used with strict adherence to cleaning regulations. In any case, using a bronchoscope (either disposable, or reusable) should not be compromised; only tubes (ETT or DLT) with embedded camera can replace the need for position confirmation by bronchoscopy. Even when using tubes with embedded cameras, bronchoscopes can still occasionally be necessary. It should be kept in mind that the most common reason for hypoxemia during thoracic anesthesia is malposition of the airway device. If a bronchoscope is not available at all:
  - A DLT can be used with clinical evaluation of the position,
  - DLT with an embedded camera can be used.
  - An EZ-blocker can be used.

Difficult intubation

- Awake intubation should be avoided where possible and should be limited to strict indications in patients with an anticipated difficult airway. In these cases, no aerosol

or vaporization should be used for airway topicalization. Titrated sedation with an infusion pump and sedation depth monitoring has to be performed.[1,4]For intubation, a flexible (preferably disposable) endoscope with a Separate Remote Screen should be used. A rescue intubation through a third generation supraglottic airway devices or early cricothyrotomy/front of neck access (FNAC) can be necessary and equipment should therfore be ready before the intubation attempt.

After intubation

- If necessary, a nasogastric tube can be placed, immediately after the intubation.
- If the diagnosis of COVID-19 is not already confirmed, a deep tracheal aspirate for virology should be taken using closed suction.
- The patient should remain connected to the breathing circuit as much as possible. A closed system with infra-glottic catheter tip should be used for suction.[4,6,11] If a disconnection from the breathing circuit is inevitably necessary, the ventilator should be switched to stand-by, and the endotracheal tube should be clamped.
- After tracheal intubation, disposable equipment should be discarded appropriatelt and reusable equipment should be immediately placed inside sheaths and decontaminated according to the manufacturer's recommendations,
  - Doffing should be performed according to the prescribed sequence (Table 2) and be monitored by the doffing observer meticulously.
  - If the intubation room is separate to the OR, this room should be cleaned 20 minutes after intubation (and after all similar aerosol generating procedures).
  - PPE should be worn until the end of the operation, after immediately changing the outer gloves.[6, 11] Otherwise, hand hygiene must be performed before and after all patient contact. For tracheal extubation, caution should be exercised in view of the

risks of aerosol transmission with coughing or need for reintubation[6, 11]. The whole donning and doffing procedure should be repeated as described.

Non-intubated thoracic surgery.

Although some guidelines for other clinical conditions advocate regional anesthesia for non-intubated surgery as an option in non-intubated, less-unwell patients to avoid the need for airway management, we do not suggest approach during thoracic surgery. Regional anesthesia would leave the airway open to the room for the duration of the procedure with risks of contagion. There is no supporting evidence or previous reports describing the non-intubated technique in patients with highly contagious diseases. Even in the "healthy" (non Covid-19) population, non-intubated thoracic surgery is a novel, less well described approach, which contrary to some beliefs, is more challenging for the anesthetist. Under the new condition with the SARS-CoV2, there may be some exceptional cases that would benefit from this approach, but overall, it should be considered as too heroic, and cannot be recommended.

It should be kept in mind that all techniques (but Helmet) of non-invasive ventilation (NIV) are associated with an increased risk of aerosol spread., It is therefore suggested that to avoid NIV and HFNO in patients undergoing thoracic surgery.

Ventilation and One-Lung ventilation

- Another antiviral filter should be applied to the end of the lumen corresponding to the non-dependent lung, which is disconnected during one-lung ventilation. This would avoid (or decrease) the risk of aerosolization through the disconnected lumen (Figure 4).

- As the oxygenation of SARS-CoV2 patients is already compromised, one-lung ventilation could be more challenging, and a higher incidence of hypoxemia during one-lung ventilation can be expected.

- Generic recommendation for the conduct of one-lung ventilation (OLV) can also be considered to be also valid in these patients:

    - FiO_2 of 100 %.
    - Low tidal volume 4-6 ml/kg predicted body weight.
    - Some degree of hypercapnia can be permitted by adjusting the respiratory frequency (pH above 7.2).
    - Potentially a higher positive end-expiratory pressure (PEEP) may be required than in a patient without COVID-19: appr 13-15 cm H_2O. A PEEP titration strategy is suggested but should be performed very cautiously not to cause a decrease in cardiac output in higher PEEP levels.
    - It is an advantage that lung compliance is usually good in SARS-CoV2 patients (as reported by the Italian group).
    - Patients may get benefit from the application of an alveolar recruitment maneuver, and a trial is recommended. It should be kept in mind however that the recruitment strategy can impair the hemodynamic stability in a more extended way than the "healthy" patients.

- Clearly in some patients with active lung disease, maintenance of OLV may be impossible due to oxygenation problems. In such cases it should be kept in mind that in cases without obligatory indications for a lung "isolation" (e.g. airway leakage, unilateral bleeding), the price to continue the OLV must never be to compromise

oxygenation. This general rule must be even more strictly adhered to in challenging cases like SARS-CoV2 patients.

- In open thoracotomies, application of CPAP to the non-dependent lung can be very useful to prevent hypoxemia. The authors suggest that the benefits to achieve sufficient oxygenation would overcome the (unproven) possibility of aerosolization from the open CPAP system.

- In some cases, application of extracorporeal assist systems (for oxygenation and/or carbon dioxide removal) can be indicated. But these cases are beyond the scope of this review.

Extubation (Figure 5)

- The authors assume that in almost all SARS-CoV2 patients undergoing thoracic surgery, mechanical ventilation may need to be continued after the operation.

- If a BB was used, it can simply be removed at the end of the operation.

- If a DLT was used, it should be changed to a normal ETT using an appropriate tube exchanger (Caveat: Specific tube exchangers for DLT's should be used), In such cases, regulations for PPE (donning and doffing) should be repeated step by step.

- If DLT was used, and an exchange to ETT may not be warranted in some circumstances (e.g. the anticipated need for a brief duration of mechanical ventilation); a classical method in such cases is –after deflating both cuffs- to pull back the DLT above the carina. Now, only the bronchial cuff can be inflated; and ventilation can be continued only via the bronchial lumen.

- It has been reported that the patients with SARS-CoV2 usually have excessive retained secretions, especially during the weaning phase. It therefore makes sense to postpone this phase to a later time frame than the immediate postoperative period.

- In patients who are to be extubated:

    - Prior to extubation, aspiration via a closed system, followed by a recruitment maneuver is suggested.
    - Patient should be ready for extubation on to facemask. Air flow to surrounding area should be avoided as much as possible. A tight-fitting facemask is therefore essential.
    - Again, aerosolizing procedures (e.g. none-invasive ventilation (NIV), high flow nasal oxygen (HFNO)) should be avoided.
    - Regarding PPE, the same level, conditions and logistics, as applied during intubation are required.
    - Any maneuver which risks precipitating coughing should be avoided: oral suctioning (if any) should be very gentle, patients should not be asked to cough. In difficult airway cases, using an extubation catheter (e.g. with a soft thin tip) can be possible, but in these cases, keeping the patient intubated is more rational.
    - Use of medication known to effectively lower the incidence of coughing (e.g. dexmedetomidine)
    - Placing a N95 or surgical face mask on the patient after extubation, with an oxygen mask immediately above could be feasible not only to prevent postoperative hypoxemia, but also to minimize aerosolization.
    - Transferring extubated patients should follow local regulations.

After extubation:

- Breathing circuit should be changed.
- Airway breathing system (ABS) and soda lime canisters should be decontaminated.
- All disposable material should be discarded; reusable material should be sent for decontamination.
- A waiting period of 20 minutes is necessary to disinfect with 3% - 5% chlorine solution.

Conclusion:

The COVID-19 “pandemic” has undoubtedly become the most important challenge for the human race in recent memory Health personnel will in all likelihood will have to deal with a wide range of COVID-19 cases undergoing different operations.

Observing the changes that the “COVID crisis” has already caused, we can foresee that the “routine life” of daily practice in our hospitals will be radically different, with all materials used for anaesthesia potentially subject to shortage in time.

This “opinion survey” has been prepared with expert opinions, and therefore cannot claim to be “evidence based” or “comprehensive”. Still, we hope that it can be helpful to our colleagues, not only for thoracic anesthesia but also to organize a general management of this challenging patient group.

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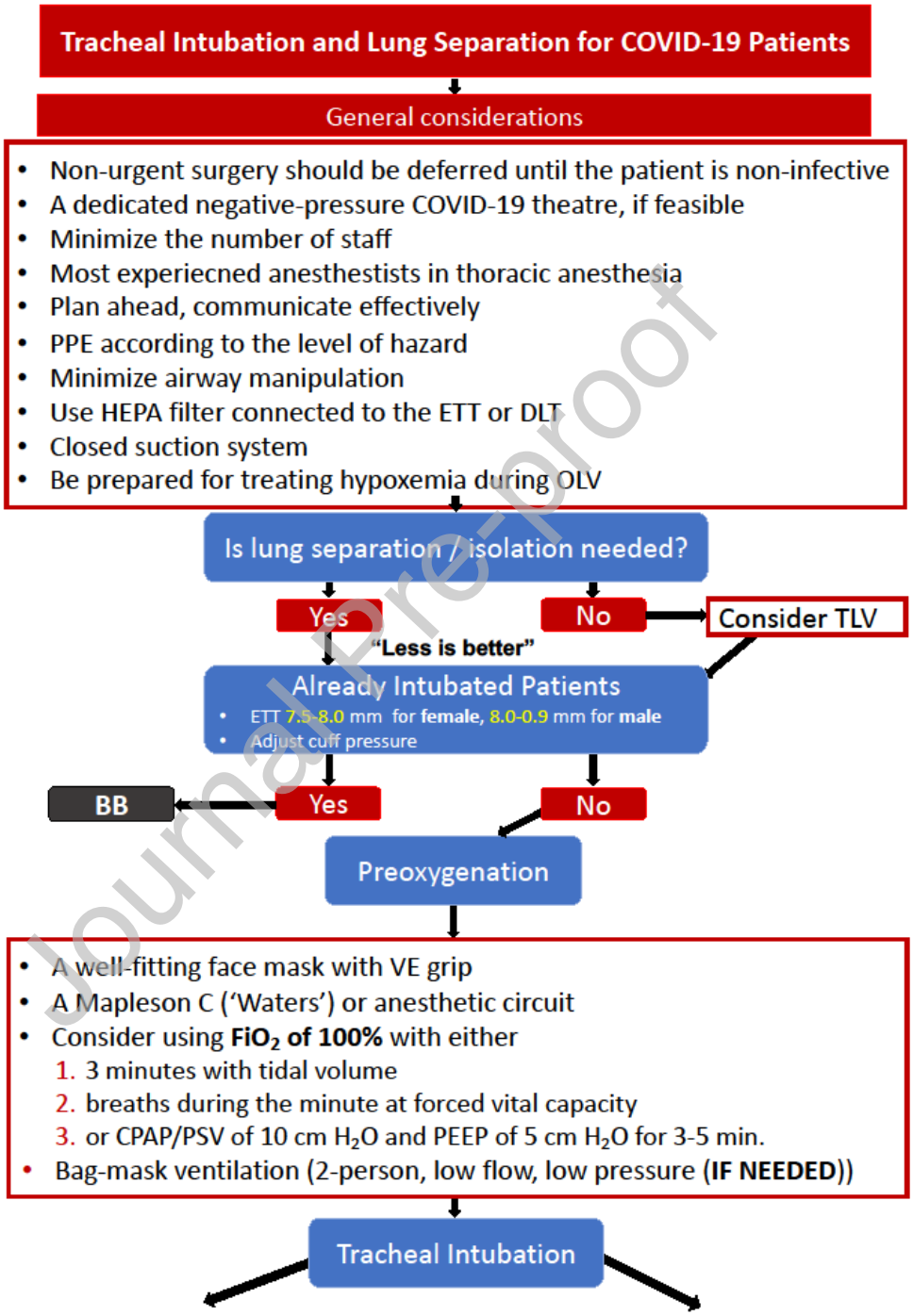
Figures Legends:

(a)



(b)

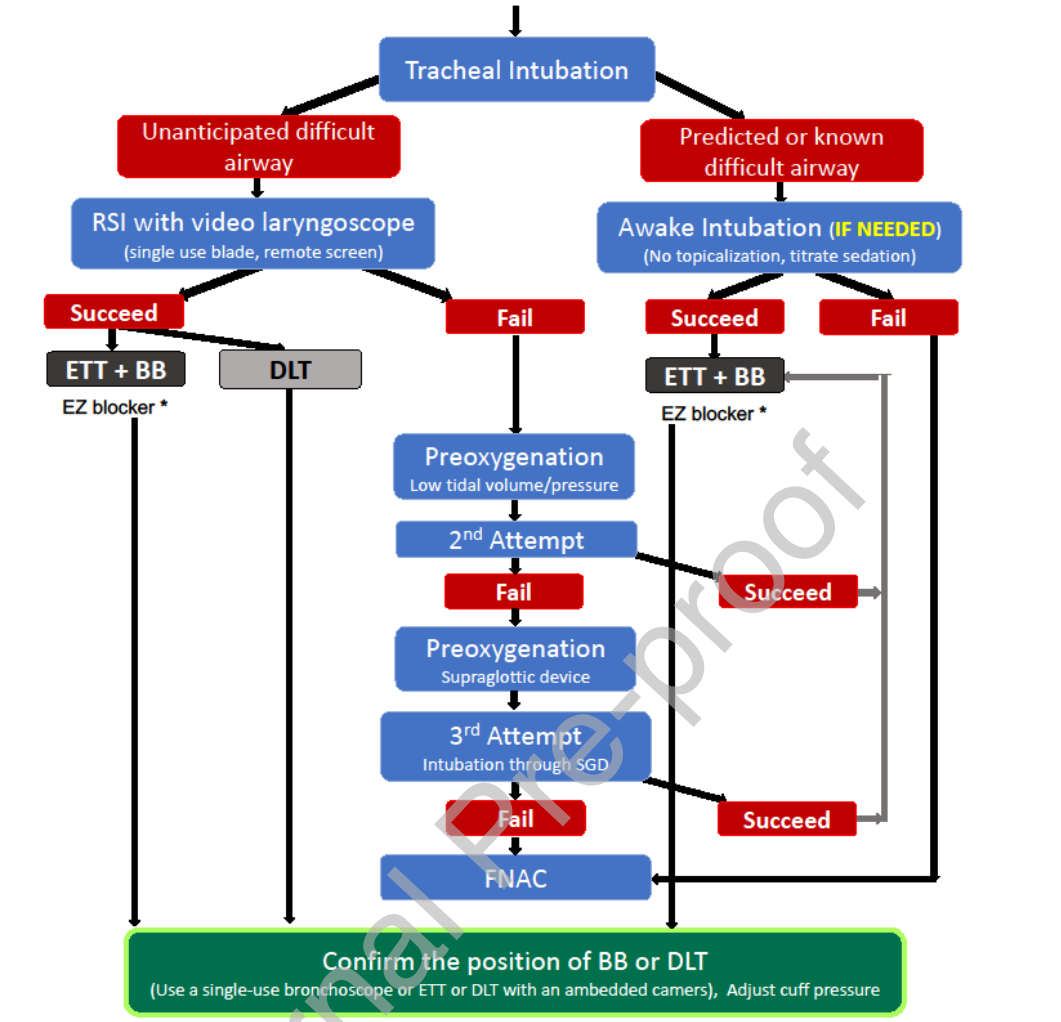


Figure (1): Systematic approach for (1a) tracheal intubation and (1b) lung separation for COVID-19 patients scheduled for thoracic surgery.

Abbreviations: PPE; protective personal equipment, HEPA; high-efficiency particulate air, ETT; endotracheal tube, DLT; double lumen tubes, OLV; one lung ventilation, TLV; two-

lung ventilation, BB; bronchial blockers. FiO_2; an inspired oxygen fraction, CPAP; continuous positive airway pressure, PSV; pressure support ventilation, PEEP; positive end-expiratory pressure, RSI; rapid sequence induction, FNAC; front of neck access.

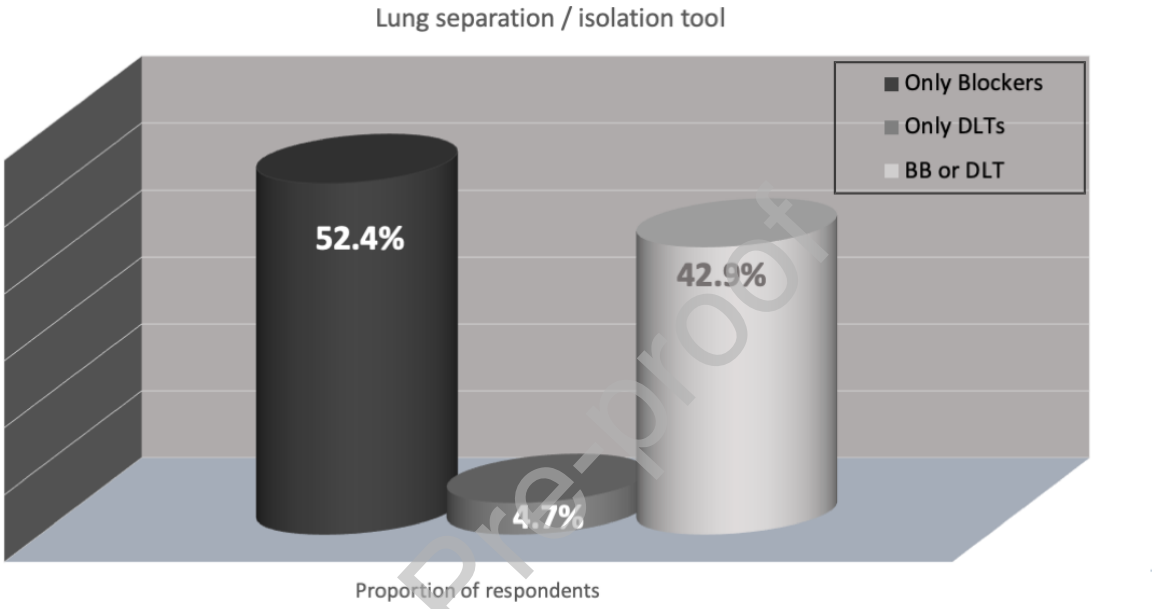


Figure (2): The lung separation tools preferably used by the respondents for COVID-19 patients. Abbreviations: DLT; double lumen tubes, BB; bronchial blockers.

The respondents would only use either a bronchial blocker (52.4%) or double lumen tube (4.7%). The remaining 47.6 % chose to use either of BB or DLT according to the intubation status (intubated vs. non-intubated), airway difficulty and duration of the surgical procedure.

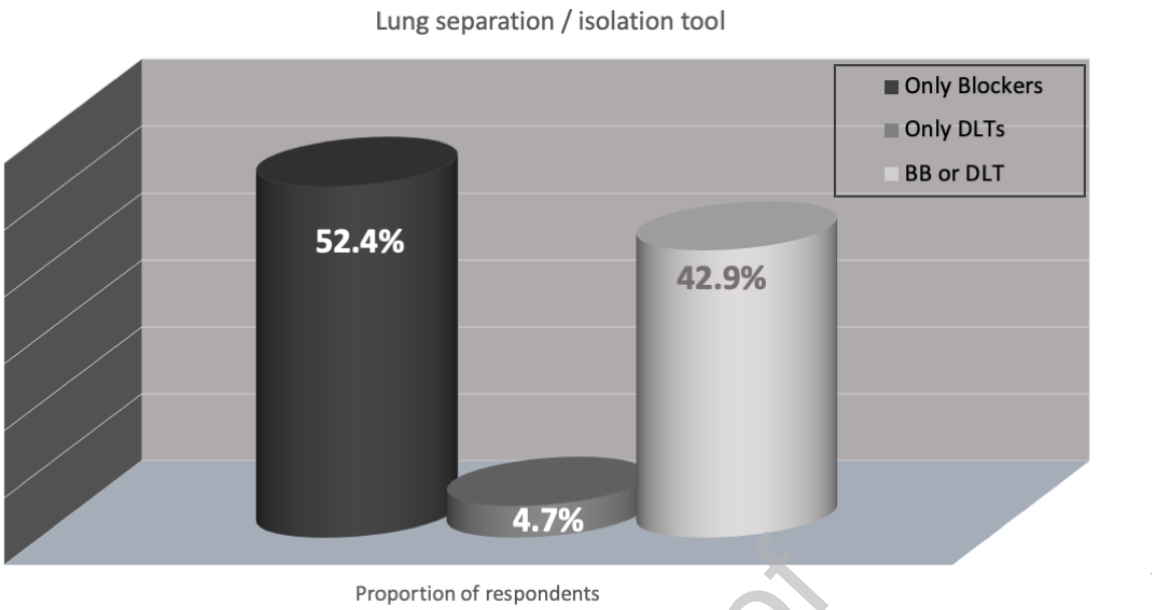


Figure (3): Most common indications for using the bronchial blockers or double lumen tubes. Abbreviations: DLT; double lumen tubes, BB; bronchial blockers.

The use of BB for all patients is advocated by 52.4%; 33.3% would use BB in already intubated patients, and 9.5% in patients with difficult airway. On the other side, 28.6% would use DLT in all cases, and 19% only in non-intubated cases.

Figure (4): A HEPA filter connected to the double lumen tube (A permission to use was obtained from Dr. Domenico, Rome, Italy).

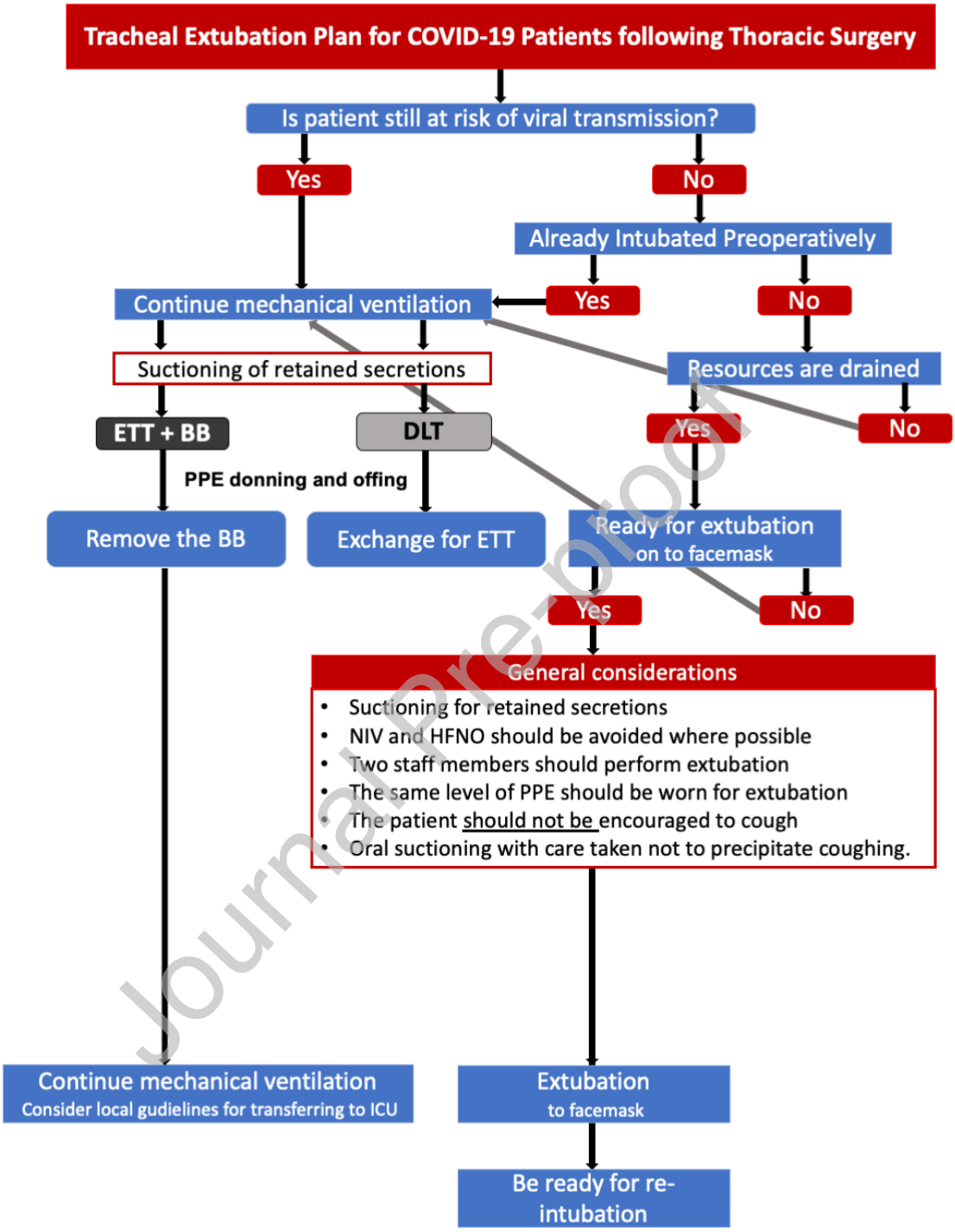


Figure (5): Systematic approach for tracheal extubation plans for COVID-19 patients scheduled for thoracic surgery.

Abbreviations: ETT; endotracheal tube, BB; bronchial blockers, DLT; double lumen tubes, PPE; protective personal equipment, NIV; noninvasive ventilation, HFNO; high flow nasal oxygen.

Table 1: Comparisons between the different societies' general recommendations on airway management

Management	UK	SIAARTI	WFSA	APSF	Canada	Australia	China
Team Safety							
Tracheal intubation is a high-risk aerosol spreading procedure	+	+	+	+	+	+	+
Prefer elective tracheal intubation	+	+	+	+	+	+	
Recommendation for PPE	+	+	+	+	+	+	
Hair cover	+	+	+	+	+	+	+
Hood		+ / cover			+ / cover		
N95 or FFP2		+	+	+	+	+	+
FFP3	+	3rd level					
Googles / eye wear	+		+	+	+	+	+
Face shield		+		+	+	+	+
Shoe cover	+	+			+		+
Double gloving	+	+	+	+	+	+	+

Long sleeve resistant gown	Plastic apron	+		+	+	+	+
HEPA or HME filters	+	+	+	+	+	+	+
Organization aspects, team communication							
An isolated negative pressure room, if available	+	+	+	+	+	+	+
Limit staff present at tracheal intubation	+	+	+	+	+	+	
Consider excluding staff vulnerable to infection from the team						+	
Effective communication	+	+	+	+	+	+	
Developed checklist	+	+					
Intubation with SAS principles							
A dedicated airway cart should be available	+	+			+	+	+
Preoxygenation							
3 – 5 min	+						
5 min		+	+	+	+	+	+
Apneic	+		+	+		+	
Tidal volume or FVC		+					+
Avoid BM ventilation if possible	+	+		+	+	+	+

RSI	+	+	+	+	+	+	+
Avoid cricoid pressure	**?**	+	-				
Ensure full neuromuscular blockade	+	+	+	+	+	+	+
Videolaryngoscopy	+	+	+	+	+	+	+
Limit awake intubation	+	+	+	+		+	
Avoid topicalization	+	+					

Abbreviations: UK; United Kingdom; SIARRTI; Società Italiana di Anestesia Analgesia Rianimazione e Terapia Intensiva, WFSA; World Federation of Societies of Anaesthesiologists, APSF; Anesthesia Patients Safety Foundation, PPE; personal protective equipment, SAS; mnemonic for the procedure “S”afe (for staff an patient), “A”ccurate (avoiding unreliable, unfamiliar or repeated techniques) AND “S”wift (timely, without rush and delay).

Table 2: Donning and Doffing of personal protective equipment (PPE)

A. Donning PPE	B. Doffing PPE
Hand hygiene	Remove outer glove – hand hygiene
Inner gloves + hygiene again	Remove shoe covers
Hair covers /hood	Remove gown
Shoe covers	Remove eye protection
Gown	Remove hair covers/hood
Mask fit check	Remove mask
Eye protection: fit check again	Remove inner glove
Outer glove	Hand hygiene

Table 3: Contents of the intubation trolley

Item	Checkboxes
PPE x 4 (These are only for anesthesia team)	□
Drugs	□
Video laryngoscope (VL) trolley with screen	□
VL blades (preferably disposable) (one of each size 3,4 and D)	□
Disposable Mapleson C breathing circuit	□
Standard endotracheal tube in appropriate sizes (3 sizes around the expected size)	□
Intubatable supraglottic airway device	□
Double lumen tubes (if not otherwise indicated: left-sided; in 2 sizes appropriate for the patient)	□
Bronchial blocker (according to the policies of the clinics)	□
Bougie (1 pc)	□
Airway exchange catheter	□
Airways in appropriate sizes	□
Sealing face mask in appropriate sizes	□
HEPA filters connected to each interface (mask with Y connection, inspiration and expiration limbs, ETT or DLT)	□
Two capnography sampling lines	□
Adhesive plaster for ETT fixation	□
Adult Magill forceps	□
Swivel connector 15 mm (with valve)	□

Stylets	□
Water- soluble gel lubricant,	□
Disposable Ambu bag with HEPA filter	□

Note that:

1. This is prepared for the anesthesia team only.
2. All disposable equipment should be discarded after the operation, even if not used.
3. Therefore, to avoid unnecessary wasting, the trolley should be prepared each time in regard for the case and the anticipatedplan.

Table 4: Indications for lung isolation: Please note that in cases of absolute lung "isolation", DLT's should be used. In other cases, the indication for BB's should be considered according the suggestions in the text.

Abbreviations: DLT; double lumen tube, BB; bronchial blocker; VL; Video-assisted thoracoscopy.

		Indications	Main goal	Suggestion
Absolute indications		Unilateral lung abscess or cyst	Contralateral Lung protection	DLT
		Unilateral lung hemorrhage (e.g., thromboembolism, aneurysm)	Contralateral Lung protection	DLT
		Bronchoalveolar lavage with saline to treat alveolar proteinosis	Contralateral Lung protection	DLT
		Bronchopulmonary fistula, trachea-bronchial injury	Secure the airways and gas exchange	DLT
		Severe unilateral disease (giant emphysematous bullae)	Differential lung ventilation	DLT
		Lung transplantation	Secure the airways and differential ventilation	DLT
Relative indications	High priority	Pneumonectomy, sleeve resection on the bronchial mainstem	Surgical exposure	DLT

		Tumor obstructing the main bronchial stem		
		Thoracic aneurysm with cardiopulmonary bypass	Surgical exposure	DLT > BB
		Lobectomy and lesser lung resection (any surgical approach[a])	Surgical exposure	DLT = BB
	Low priority	Interventions on the pleura and mediastinal structures	Surgical exposure	DLT = BB
		Esophagectomy	Surgical exposure	DLT = BB
		Orthopedic surgery on the chest, thoracic spine surgery	Surgical exposure	DLT = BB
		Minimally invasive cardiac surgery	Surgical exposure	DLT = BB
		Bilateral cervical sympathectomy	Surgical exposure	BBs > DLT