



Flexible bronchoscopy during mechanical ventilation. Why and why not

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Abstract

Flexible bronchoscopy has been utilized in the intensive care units and in mechanically ventilated patients for many decades. The procedure is reasonably safe and has wide range of diagnostic and therapeutic benefits in patients undergoing mechanical ventilation.

Though guidelines exist for bronchoscopy in adults in general and for those in the intensive care units (ICU), there are no guidelines specifically established for bronchoscopy during mechanical ventilation.

In this review, we try to summarize the indications (Why), physiologic effects of bronchoscopy, complications, and the contraindications (Why not) to the use of this procedure and the evidence behind it.

Special section on the single use disposable bronchoscopes and the use of bronchoscopy during the COVID-19 era are discussed

Keywords: Flexible bronchoscopy, Acute respiratory failure, Mechanical ventilation, COVID-19, Disposable bronchoscopy

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Introduction

Since its introduction for commercial use in the late 1980s, flexible bronchoscopy has gained popularity and an increased diagnostic and therapeutic roles in many respiratory diseases in the ICU especially during mechanical ventilation. The technology has evolved significantly over the decades from eye piece fiberoptic scopes to video scopes with high-definition monitors.

The advances in technology have introduced more indications and capabilities to the flexible bronchoscopy. Endobronchial ultrasonography,¹ cryotherapy,² and airway stents³ are few examples.

Indication

Bronchoscopy during mechanical ventilation has two main functions: to aid in diagnosis and for therapeutic interventions. Those indications are summarized in table 1 and figure 1.

The indication for diagnostic bronchoscopy is to further explain and definitively evaluate symptoms and radiological findings of trachea-bronchial and lung disease such as: excessive secretion, hemoptysis, localized atelectasis; collection of lower airway secretions to diagnose pneumonia, persistent atelectasis, lung masses, or suspected airway obstruction, tracheobronchomalacia, tracheoesophageal fistula, bronchopleural fistula.

Flexible bronchoscopy is used extensively in clinical practice to diagnose hospital acquired pneumonia (HAP) and ventilator associated pneumonia (VAP) to obtain broncho-alveolar lavage (BAL) or protected specimen brush (PSB). However the latest guidelines from the IDSA/ATS⁴ recommends “noninvasive sampling with semiquantitative cultures to diagnose VAP, rather than invasive sampling with quantitative cultures and rather than noninvasive sampling with quantitative cultures”.

Therapeutic bronchoscopy is used for removal of foreign bodies although rigid bronchoscopy is ideal for larger and more proximal obstructions. Endobronchial obstruction by secretions and mucus can be cleared, as well as drainage of lung abscesses.

Interventional procedures like balloon dilation and possible stenting are indicated for tracheal stenosis, bronchomalacia and refractory atelectasis. Control of hemoptysis through injection of epinephrine or using cryotherapy is effective, although rigid bronchoscope might be needed for massive hemoptysis.

Flexible bronchoscopy is also used for the difficult intubation cases. In the most recent guidelines for the difficult airway,⁵ bronchoscopy is one of the options to secure the artificial airway with high success rate. Additionally it is used to confirm the position of the artificial airways, and in the adequate positioning of double-lumen endotracheal tube placements.⁶

Bedside percutaneous tracheostomy placement has been increasingly performed and shown to be safer than the open surgical tracheostomy. Flexible bronchoscopy plays a major role in the procedure, allowing continuous direct visual guidance to avoid injury to the posterior tracheal wall.⁷

Diagnostic

- Airway obstruction
- Airway anomalies
- Tracheomalacia
- Foreign body
- Hemoptysis
- Atelectasis
- Pneumonia
- Lung mass
- Inhalation injuries/Burns

Therapeutic

- Airway clearance
- Foreign body retrieval
- Control of hemoptysis
- Drainage of lung abscess
- Endotracheal intubation and positioning
- Percutaneous dilatational tracheostomy
- Placement of airway stents

Table 1: Diagnostic and therapeutic indications for flexible bronchoscopy during mechanical ventilation

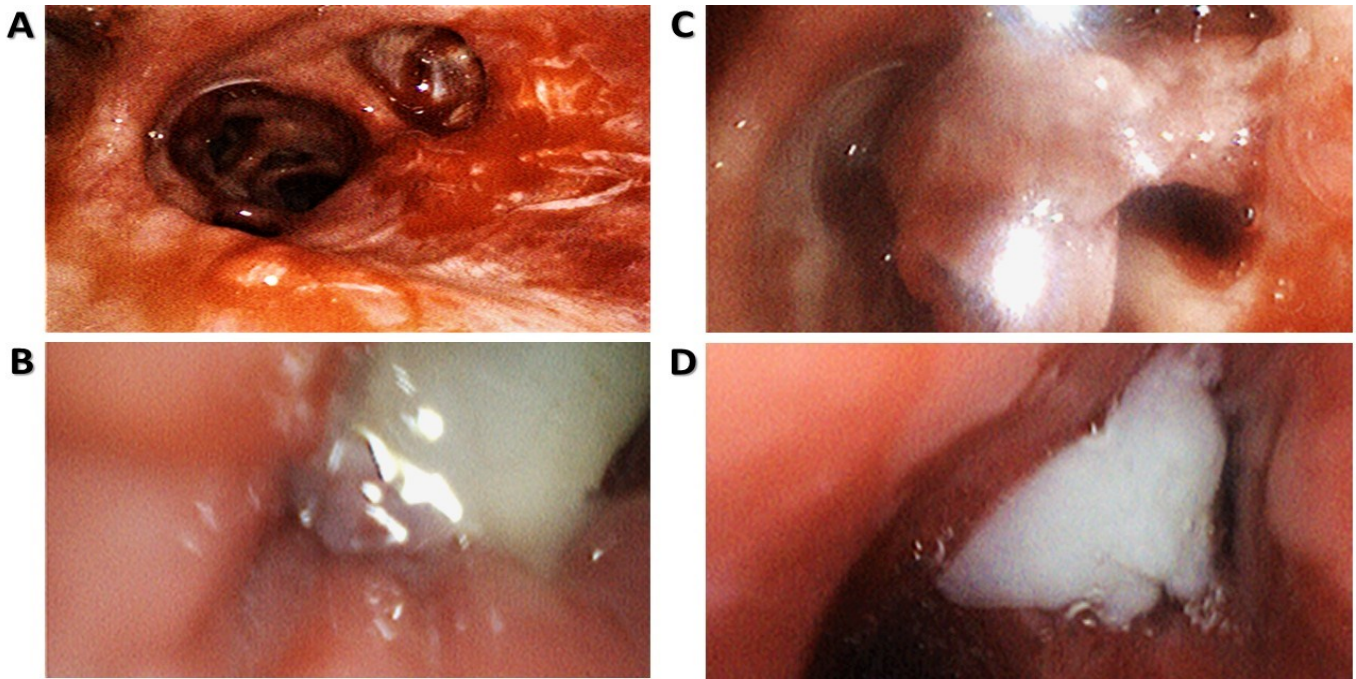


Figure 1: Examples of disorders diagnosed and treated with flexible bronchoscopy during mechanical ventilation
A: Hemoptysis from the right upper lobe. B: Foreign body (broken tooth) in the bronchus intermedius. C: Endobronchial mass (cancer). D: Mucus plug occluding segmental bronchus

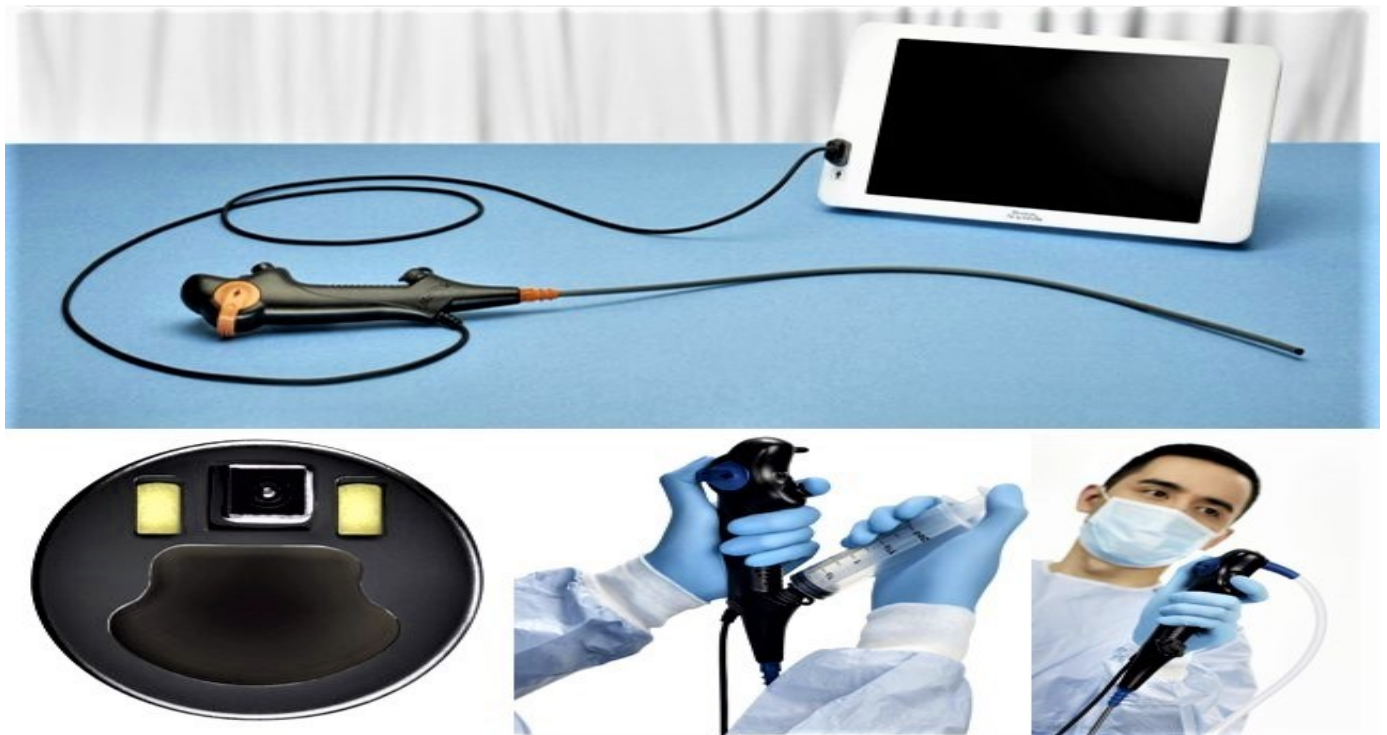


Figure 2: Example of disposable bronchoscopes (EXALT™ Model B). Gift from Boston Scientific with permission.
Top: scope attached to the monitor. Bottom left: cross section of the scope showing the working/suction channel. Bottom middle and right: connection of the scope to suction and injection channels.

Cardio-Pulmonary effects of bronchoscopy

Several physiologic effects can affect the cardio-pulmonary system during bronchoscopy.

- Airway resistance: Depending on the size of the bronchoscope and the artificial airway, the bronchoscope may occlude 40-70% of the diameter of the artificial airway which significantly increase airway resistance causing increased airway pressure and intrinsic PEEP (PEEP_i)^{8,9}
- Lung compliance: the repeated suctioning can lead to loss of the tidal volume and atelectasis, additionally the installation of fluids for sampling can lead to dilution of surfactant also causing alveolar collapse and atelectasis¹⁰
- Hypoxia and hypercapnia can happen transiently but usually recovers
- The above effects can cause increase the pulmonary artery pressure which might reduce the cardiac output.
- Increased sympathetic drive can increase heart rate and cardiac output

Complications

Serious complications and mortality are rare during flexible bronchoscopy estimated at 1.1% and 0.02% respectively. Complications are usually not severe, but serious complications occur more frequently in ICU patients, those on mechanical ventilation, those with coagulation abnormalities or anticoagulant/antiplatelet agents and those undergoing biopsies.^{11,12}

The pros and cons of risks and benefits should be assessed carefully before the procedure, and the clinician should take the time to explain them to the patients or their surrogates so an informed consent can be obtained.

Complications are summarized in table 2.

Contraindications

There are no absolute contraindications for flexible bronchoscopy in ICU patients but given the higher risks of complications in the mechanically ventilated patients, many of them have relative contraindications. Some of those contraindications are based on experts’ opinions more than evidence-based studies. Careful risk-benefit analysis is required, and elective or non-emergent indications can be delayed. There are some logically agreed upon relative contraindications^{13,14,15,16,17,18,19} that are summarized in table 3.

Complications
Bleeding
Pneumothorax
Severe hypoxemia
Worsening ventilation
Cardiac arrhythmias
Myocardial ischemia
Seizures
Laryngospasm
Increased intracranial pressure (ICP)
Complications of sedation

Table 2 Potential complications

Contraindications
Pneumothorax untreated
Severe hypoxemia (PaO ₂ < 60 on FiO ₂ > 80-100%, PEEP > 10 cmH ₂ O
Severe hypercapnia with respiratory acidemia (PH < 7.2)
Severe thrombocytopenia (< 30,000 – 50,000)
Anticoagulation / Antiplatelets
Uncontrolled cardiac arrhythmias
Active myocardial ischemia
Severe hemodynamic compromise
Severe pulmonary hypertension
Elevated ICP
Lack of informed consent unless emergent procedure
Lack of expert bronchoscopist

Table 3 Agreed upon contraindications

Preparation for the procedure

Before the procedure is performed, it is important to assign specific roles for those involved in the procedure. Assuring all medications including sedatives, local anesthetics, and other needed medications are available. All required equipment including suctioning devices, adaptors, sample collection, and additional bronchoscopy accessories like forceps, baskets are available if needed (Figure 3).

A careful evaluation of the patients' hemodynamic and respiratory status is necessary. Additionally careful evaluation of the size of the outer diameter of the bronchoscope and the inner diameter of the artificial airway should be undertaken to reduce the risks mentioned above.

The FiO₂ should be increased to 100% before the procedure, and continuous monitoring of oxygenation and ventilation via SpO₂ and end tidal carbon dioxide (ETCO₂), ECG should be available.



Figure 3: examples of equipment that might be required during the procedure. Swivel adaptors, specimen traps, different forceps, and retrieval basket.

Bronchoscopy during Non-Invasive ventilation

Non-invasive ventilation including positive pressure with masks or with the high flow nasal cannula are used more frequently in patients with respiratory disease of various etiology.

The feasibility to perform bronchoscopy for patients on or with the aid of those devices have been evaluated to avoid the risks and complications.^{20,21}

Special careful monitoring of oxygenation and ventilation, and the presence of a qualified clinician capable of securing an airway is prudent in case clinical deterioration occurs.

Bronchoscopy for COVID-19 patients

The necessity of bronchoscopy procedure during the COVID-19 pandemic must be taken into adequate consideration given it is an aerosol generating procedure. The indications are relatively more urgent than non-COVID bronchoscopy; suspicion of superinfection, atelectasis concerning for mucus plug, percutaneous tracheostomy, emergent intervention such as significant hemoptysis, severe central airway obstruction, foreign body.²² In our facility, percutaneous tracheostomy is the major reason for bronchoscopy of COVID-19 patients; normally for failure to liberate off the ventilator.

When a bronchoscopy procedure is performed, prescreening is recommended to evaluate the patient's condition including chest x-ray, platelet counts, medication history of anti-platelet agents or anticoagulants, ejection fraction, hemodynamic and oxygenation status.

A brief pre-rounding huddle is recommended to share the information and recognize each clinician's role during the procedure to shorten the procedure time. Full personal protective equipment (PPE) is utilized. Staff in attendance should be minimized to avoid exposure to infection and save PPE.²³ A negative pressure room if available is indispensable. A disposable bronchoscope is strongly recommended as well.

When hemoptysis exists or is suspected, agents such as epinephrine or additional equipment should be prepared in advance to shorten time of the procedure. After the procedure, chest x-ray might be needed to rule out pneumothorax for high risk patients.

Brief reports showed that the procedure for COVID-19 patients is relatively safe, though risks for staff contacting the infection is possible.²⁴

Disposable bronchoscopy

In recent years, single use disposable bronchoscopies have emerged as an alternative to the conventional bronchoscopes. These flexible scopes come from different manufacturers with a variety of sizes and monitors.

The proposed benefits of these devices are that they might be slightly less expensive, more readily available, easier to assemble and more portable which might reduce the time needed to prepare for the procedure, along with the prevention of cross contamination and infection risks.^{25,26,27}

The quality of monitors, video acquisition, suctioning, and maneuverability of these scopes vary from one to another. As the technology of these devices continues to evolve and improve, more studies are needed before asserting any superiority compared to the reusable conventional bronchoscopes.

Some studies comparing these scopes to the conventional ones found that they are equivalent in performance in the ICU. In addition, they may confer clinical, economic, and logistical advantages over the conventional scopes.²⁸

The American Association for Bronchology and Interventional Pulmonology (AABIP) statement on COVID-19 state that “disposable bronchoscopes should be used first line when available” in patients with suspected or confirmed COVID-19 infection.²⁹

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