Bronchoscopy in Intensive Care Unit

L. Fecci[1], G.F. Consigli[2]

[1] U.O. di Pneumologia e Endoscopia Toracica, Azienda Ospedaliera Universitaria di Parma,
[2] U.O. Fisiopatologia Respiratoria e Lungodegenza, Azienda Ospedaliera Universitaria di Parma, Italy.

Correspondence: Dr. Luigi Fecci, Via Silvio Pellico 30, 43100 Parma, Italy; e-mail: luigi.fecci@gmail.com

Fiberoptic bronchoscopy (FBS) is a relatively safe procedure, commonly used in intensive care, both to monitor and maintain airways and for the diagnosis the pathology of the pulmonary parenchyma [1, 2]. It is usually practiced in emergency conditions on critically ill patients, who are intubated by controlled ventilation or by non-invasive assisted ventilation. In the latter case bronchoscopy is frequently and easily performed on patients in an iron lung but it can also be performed, though less easily, on patients ventilated by facemask.

Recommendation

- **Urgent fiberoptic bronchoscopy must be quickly and easily carried out in intensive care for diagnostic and therapeutic purposes where indicated (Grade C).**

Problems due to clinical conditions

Patients in Intensive Care Unit (ICU) following trauma, surgery or other serious pathology, can exhibit some or all of the clinical conditions that increase the risk of a bronchoscopy. These patients often have respiratory failure, they may have serious cardio-circulatory problems or may present problems with important organs such as kidneys, liver or central nervous system [3]. It is therefore necessary to be aware of the risks associated with these clinical conditions in order to prevent, or adequately deal with the subsequent complications that may arise [4].

Recommendation

- **Patients in intensive care should be considered as 'high risk' of developing complications during bronchoscopy (Grade B).**

Problems due to methodology

Diameter of endotracheal tube

In a non-intubated subject who is breathing spontaneously, FBS results in a 10-15% reduction in the cross sectional area of the trachea, depending on the size of the instrument used. This causes no significant alteration of the pressure within the trachea. In an intubated and mechanically ventilated patient, however, there may be difficulty in the passage of the instrument through the tube and damage to the tube itself a FBS with a diameter of 5.7 mm occupies 40% of the lumen of a 9 mm endotracheal tube and 66% of that of a 7 mm tube with a consequent alteration of ventilation [5]. This also applies to tracheal cannulae, which are even more rigid and angulated than endotracheal tubes. A careful lubrication of the instrument is essential to prevent these problems.

Alteration of ventilatory mechanics

The alterations in ventilation and haemodynamics during FBS have been clearly documented in numerous studies both in intubated and non intubated patients [6-12]. The presence of the bronchoscope within the endotracheal tube increases resistance causing an incomplete emptying of the lung in expiration and a significant increase of pressure during the inspiratory phase, which can then peak at significantly high levels in expiration. Intrinsic positive end-expiratory pressure (PEEPi) remains persistently elevated [7].

Alterations in gas exchange

The alteration in respiratory mechanics secondary to the obstruction of the airways caused by the presence of the bronchoscope within the endotracheal tube and sometimes also due to bronchospasm, can also effect gas exchange with a fall in PaO_2 and a slight rise in $PaCO_2$, probably due to the reduction in flow volume. These levels can deteriorate during aspiration due to the subtraction of

Tidal Volume (TV) from gas exchange and the collapse of alveoli due to suction [8].

Haemodynamic alterations

The haemodynamic alterations most frequently encountered are alterations of heart rate, of systolic arterial pressure, an elevation cardiac output and of wedge pressure. When PEEPi reaches elevated levels, a fall in cardiac output and blood pressure can be observed [4, 8].

High risk of transmission of infection

ICUs carry a notoriously high risk of transmission of infection from patient to patient. Because of this, careful attention must be paid to the sterility of the instrument in all endoscopic procedures.

Anaesthetic technique

Optimal anaesthesia should guarantee perfect adaptation of the patient to the ventilator. This is obtained with sedation (propofol or midazolam are usually used) and neuromuscular block (short acting formulations of curare are preferred) [10]. Neuromuscular block with curare is particularly useful because it eliminates coughing which is troublesome for a good execution of the procedure and which is particularly dangerous in patients with intracranial hypertension, it helps adaptation of the patient to the respirator and protects the instrument from biting when transoral bronchoscopy is practiced [11, 12]. FIO_2 must be increased to 100% before the examination and maintained during the procedure in order to adequately control hypoxia. If mechanical ventilation with PEEP is used, PEEP should be discontinued during the procedure for the reasons set out above.

> **Recommendation**
>
> • **Before carrying out the procedure it is necessary to ensure that the diameter of the endotracheal tube is appropriate for the diameter of the endoscope, oral intubation is preferable as it allows the use of larger tubes and connections should be leak-proof and made of soft materials that will not damage the endoscope (Grade B).**

Endoscopic technique

Before execution, the dimension of the endotracheal tube or cannula must be ascertained and the most appropriate instrument chosen according to tube diameter. When practicing the removal of a bronchial obstruction a suction channel must be used that will allow aspiration of copious dense material, so an oro-tracheal tube of at least 8 mm diameter is preferred. The oro-tracheal route carries the risk of crushing of the endoscope and this should be avoided by using the appropriate mouth guard or by adequate neuromuscular block with curare. To avoid damage to the endoscope sheath, sufficient lubrication of the endoscope with suitable products must be practiced, and particular attention must given to the choice of "T" junction inserted on the tube which must be soft enough to allow the endoscope to pass easily and without damage, but sufficiently well fitting to prevent leakage from the tube.

Suction must be reduced as much as possible and the exam must not be too prolonged [13-16].

Monitoring

ECG, blood pressure, oximetry and parameters imposed by the ventilator must be monitored during and after the exam. These ventilator parameters are Minute Ventilation (MV), TV, Peak Intratracheal Pressure (PITP), PEEP, Respiratory Rate (RR), and they should be monitored by an intensive care specialist while the endoscopist is performing bronchoscopy [17].

> **Recommendation**
>
> • **There must be constant monitoring of vital parameters during and after the bronchoscopy (Grade B).**

Indications

Indications for carrying out a fiberoptic bronchoscopy in ICU can be diagnostic and therapeutic: diagnosis and therapy of atelectasis, diagnosis of Ventilator Associated Pneumonia (VAP), and of disorders involving the alveolar-interstitial interface, difficult intubations and guidance of double lumen endotracheal tubes, diagnosis and therapy of tracheo-bronchial obstruction, aiding the execution of percutaneous tracheostomy (PDT) and diagnosis of iatrogenic lesions of the trachea.

Diagnosis and therapy of atelectasis

Variably widespread atelectasis, is a frequent occurrence in Intensive Care and can be caused by retention of dense secretions, with the formation of mucous plugs that obstruct the large bronchi, or pooling of mucous in peripheral bronchi due to reduced mucociliary clearance and inefficient cough. If inadequately treated these can cause the alteration of gas exchange with significant hypoxia, an increase in the work of respiration and infections in the lower airways. Bronchoscopy is necessary to evaluate the bronchial lumen, to remove obstruction in the airways if necessary and permit the re-expansion of the pulmonary parenchyma. When secretions are particularly dense it is necessary to use an instrument with an adequate working chan-

nel and to dilute by instilling saline solution or mucolytics. There is no consensus in the literature on the superiority of bronchoscopy relative to physio-kinetic therapy (PKT) but endoscopy is considered advisable in recent, widespread atelectasis with blood gases alterations, where PKT has not been effective or where inhalation or presence of a foreign body is supected [18-21].

Pneumonia

VAP, which can occur in the first 4 days of mechanical ventilation (Early-onset) or in the days following (Late-onset) [22], has an incidence which varies from 8 to 28% and it is associated with increased mortality, longer hospital stays and increased cost [23].

Therapy can be initiated empirically, with broadspectrum antibiotics, or it can be targeted on the basis of the *in vitro* sensitivities of the isolated bacterial colonies to an antibiotics and the initial choice of therapy determines the progress of the illness [24-27]. It has been shown that empirical therapy with broad spectrum antibiotics results in an increased number of infections with resistant germs and increased mortality with respect to targeted therapy [28, 29]. The culture sampled from the airways may be obtained in a non-invasive manner (tracheal aspiration), or using an invasive method with FBS such as bronchoalveolar lavage (BAL), protected brushing or transbronchial lung biopsy (TBLB) or with trans-bronchial needle aspiration. There is no consensus as to which method is preferable or which timing is best.

The qualitative microbiological analysis of the endo-bronchial material is complicated by the high proportion of false positives due to the colonisation of the respiratory tree that occurs straight after intubation. There is broad concurrence that a quantitative analysis is essential for a correct aetiological diagnosis [30-32].

Endotracheal aspiration (10^3 -10^7 cfu/ml) gives a sensitivity of 68% and a specificity of 84% [33].

BAL for microbiological analysis is a relatively safe, low cost procedure that allows sampling of a vast area of parenchyma.

Protected brushing is safe, more costly than BAL and presents a sensitivity of 89% and a specificity of 94%.

Invasive methods are associated with a reduced mortality after two weeks, an earlier improvement in organ functionality and a reduced use of antibiotics (more days without antibiotic therapy) [34].

Disorders involving the alveolar-interstitial interface

In addition to VAP, the ventilated patient often presents disorders involving the alveolar-interstitial interface of various types which are often difficult to diagnose: Acute Respiratory Distress Syndrome (ARDS), primary and secondary inflammatory processes, neoplasms and contusions. Early diagnosis is very important in such cases and FBS can be very helpful. In these circumstances BAL for bacteriological, immunological and cytological analysis and TBLB for histological analysis are recommended. The first is well tolerated and relatively safe whereas TBLB can be complicated by pneumothorax and haemorrhage and is reserved for diagnosis in immunocompromised patients and in the early stages of ARDS [35-38].

Difficult intubations

Intubation with FBS is a manoeuvre required in specific circumstances; when it is not possible to achieve sufficient extension of the neck, a sufficient opening of the mouth or because of anatomical variation of the airways. The procedure can often be pre-planned, especially in the case of surgical intervention though sometimes an emergency procedure is necessary, often with serious clinical conditions. The indications are specified in 'Guidelines for Emergency Tracheal Intubation' and in the classifications of Cormack and Mallampati [39, 40].

It can be carried out via the nasal or oral route. The former is indicated where the use of reinforced tubes or tubes of large size are not necessary or when oral access is not possible for surgical (maxillofacial or plastic surgery) or pathological reasons. Smaller and softer tubes are necessary, and the trans-nasal route may cause nose bleeding and sinusitis. The oral route is preferable where reinforced tubes or tubes of large size must be used or the nasal route is not accessible. This route presents slightly greater technical difficulties and it carries the risk of crushing the endoscope by biting.

The double endotracheal tube, either of left hand or right hand type, is indicated where a thoracic procedure requires the exclusion of one lung. It is inserted in the trachea using a laryngoscope and the endoscope can be used to ensure that it is correctly placed. A 3.5 mm endoscope is indicated in this situation because larger instruments will not pass through the two tracheal and bronchial tubes. Sometimes for anatomical reasons, it is not possible to use a double lumen endotracheal tube, in this case a single tube with a balloon catheter may be used. After introducing the tube in the trachea, the endoscope is used to guide the catheter in to the desired bronchus and correctly position and inflate the balloon.

Diagnosis and treatment of tracheal stenoses

Tracheal stenoses can be caused by lesions of the tracheal wall by tube or cannula and the consequent formation of granuloma and scar tissue. The endoscope is most useful in prevention to check the navigability of the trachea and in diagnosis and treatment.

Recommendation

- **A bronchoscopic inspection is advised before de-canulation to reveal a possible laryngeal or tracheal stenosis (Grade C).**

Assistance in the execution of percutaneous tracheostomy, replacement and inspection of tracheal cannulae

Endoscopic guidance during the execution of a percutaneous tracheostomy allows the procedure to be carried out correctly and reduces complications. The endoscope can be very useful in the care of the tracheostomised patient [41, 42].

Recommendation

- **Endoscopic guidance during execution of percutaneous tracheostomy reduces risk of complications (Grade C).**

Diagnosis of tracheo-oesophageal fistula

Fiberoptic bronchoscopy is the preferred examination in the diagnosis of fistulae and tracheal lacerations [43].

Summary of Recommendations

- **Urgent fiberoptic bronchoscopy must be quickly and easily carried out in intensive care for diagnostic and therapeutic purposes where indicated (Grade C).**
- **Patients in intensive care should be considered as 'high risk' of developing complications during bronchoscopy (Grade B).**
- **Before carrying out the procedure it is necessary to ensure that the diameter of the endotracheal tube is appropriate for the diameter of the endoscope, oral intubation is preferable as it allows the use of larger tubes and connections should be leak-proof and made of soft materials that will not damage the endoscope (Grade B).**
- **There must be constant monitoring of vital parameters during and after the bronchoscopy (Grade B).**
- **A bronchoscopic inspection is advised before de-canulation to reveal a possible laryngeal or tracheal stenosis (Grade C).**
- **Endoscopic guidance during execution of percutaneous tracheostomy reduces risk of complications (Grade C).**

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Pavia - Piazza Duomo