Developments in NIV: unusual applications and new modes

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AIMS

- Understand the risks associated with endoscopy in hypoxemic patients
- Understand the principles of NIV during bronchoscopy
- Familiar with practical issues related to NIV during endoscopy
- Understand the principles of noninvasive NAVA

SUMMARY

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Introduction

Endoscopy is frequently performed for diagnostic or therapeutic purposes, but is an invasive procedure with associated risks. For instance, in patients with hypoxic or hypercapnic failure endoscopy impose a considerable risk of pulmonary complications and to a lesser degree cardiac complications. In high-risk patients, in whom noninvasive diagnostic tests are inconclusive, the clinician needs to decide either to proceed with empirical treatment or endotracheal intubation to allow endoscopy, for instance bronchoscopy or transesophageal echocardiography. It should be noted that both options are unattractive. For instance, in immune-compromised patients the differential diagnosis of pulmonary infiltrates may be extensive, making it difficult to decide for reasonable empirical treatment. On the other hand, endotracheal intubation results in high costs and imposes an considerable risk for the patient. In the last decade several studies have demonstrated the feasibility of noninvasive ventilation, as an alternative to endotracheal intubation to facilitate endoscopy in hypoxemic patients. Noninvasive ventilation may reduce the risks associated with endotracheal intubation and reduce healthcare costs, although the latter has never been formally evaluated.

This chapter will discuss how noninvasive ventilation may facilitate endoscopy, in particular flexible bronchoscopy. We will not discuss the role of noninvasive ventilation as a rescue strategy when severe hypoxemia develops during bronchoscopy, as this will be discussed elsewhere in this book (Chapter XX).

Risks of bronchoscopy in hypoxemic patients

The risk of complications associated with flexible bronchoscopy in patients without comorbidities is low. However hypoxemic patients and to a lesser degree hypercapnic patients may be at risk for complications during or after bronchoscopy, in particular if this procedure is combined with bronchoalveolar lavage. In one study, bronchoscopy in hypoxemic patients (mean Pao2/Fio2 below 200 mmHg) was complicated by the need to increase Fio2 or initiation of noninvasive ventilation in 35% of the patients and endotracheal intubation in 15% within 24 hours after bronchoscopy. Clinicians should be aware of the risks associated with bronchoscopy in hypoxemic patients.
Benefit of noninvasive ventilation during bronchoscopy

Bronchoscopy may increase pulmonary shunt fraction through at least two mechanisms: first, with broncho-alveolar lavage surfactant will be lost promoting lung collapse. Second, strong suctioning through the bronchoscope may promote lung collapse. In addition, the introduction of a bronchoscope in the central airways will increase airway resistance and such the work of breathing. As noninvasive ventilation both recruit lung tissue through application of positive end expiratory pressure (PEEP) and reduce the work of breathing by application of inspiratory support, there is reasonable rationale to use noninvasive ventilation during bronchoscopy in hypoxemic patients. Indeed, several clinical studies have demonstrated that noninvasive ventilation prevents oxygen desaturation during and after bronchoscopy.

Practical aspects of noninvasive ventilation during flexible bronchoscopy

1. Patient selection

In general, hypoxemic patients will benefit the most from noninvasive ventilation during bronchoscopy. The reduction in arterial oxygen pressure (Pao2) during bronchoscopy is ~1.0 kPa but after bronchoalveolar lavage Pao2 may decrease by 3.0 kPa. In our hospital, we use noninvasive ventilation to facilitate bronchoscopy when an experienced pulmonologist deems risks for pulmonary complications as high. From our experience a Pao2 / Fio2 value below 200 mmHg is a reasonable cut off value for the application of NIV, but clinical evaluation is equally important. No safe lower threshold for oxygenation is defined, but from our experience bronchoalveolar lavage can be performed safely in patients with Pao2 / Fio2 around 140 mmHg under noninvasive ventilation.

Bronchoscopy may be performed for diagnostic or therapeutic purposes. Under both conditions, noninvasive ventilation should be considered when the patient is hypoxemic or in respiratory distress. Contraindications are those related to noninvasive ventilation and are discussed elsewhere in this book in detail. Specifically to this procedure, if Spo2 cannot be increased to at least 90% despite appropriate PEEP and high Fio2, bronchoalveolar lavage should not be performed without endotracheal intubation. If the reason for bronchoscopy were the presence of atelectasis, it would be anticipated that oxygenation increases after bronchoscopy and the clinician could consider proceeding despite low initial oxygen saturation.

2. Environment and monitoring

Despite the use of noninvasive ventilation these patients are at risk for cardio-pulmonary complications during and after bronchoscopy. Therefore the procedure should be performed in an environment where personnel and equipment is available for urgent endotracheal intubation, such as an ICU or PACU. In addition, endoscopy should be performed by an experienced clinician to limit duration of the procedure and enhance the yield of the lavage.

3. Analgesia / sedation

Topical anaesthesia, for instance Xylocain, should be applied to the upper airways and requires brief discontinuation of noninvasive ventilation. Whether or not intravenous sedatives are administered depends on patient preference. First choice sedative for this purpose is propofol, titrated to moderate sedation, either as repeated intravenous bolus or continuous infusion, based on intensivists’ preference. The advantage of propofol is its short half-life and rather predictable effect. However, no antidote is available. In addition to that alfentanyl is provided. Appropriate continuous monitoring of peripheral oxygen saturation and heart rhythm is necessary with the use of intravenous sedatives.
4. Interface

Many types of interfaces have been used in the past. We have modified a full face mask for this purpose. A synthetic cylinder (from a swivel connector) was secured in the interface. A disposable cap sealed the cylinder to allow the introduction of the bronchoscope without increasing the amount of leak (figure 1). Alternatively, a commercially available disposable ‘bronchoscopy elbow’ with an airtight diaphragm can be connected to specific interfaces, allowing the introduction of the bronchoscope (figure 2 and 3). Other interfaces, such as the helmet have been proven successful for this purpose as well. The final choice of interface depends on clinician’s experience and patient preference.

5. Application of NIV

In patents unfamiliar with noninvasive ventilation, a period of habituation for 15 – 20 minutes is recommended prior to endoscopy. The level of PEEP and pressure support should be individually titrated during this time period. In general PEEP level of 5 – 8 cmH2O and pressure support of 10 – 15 cmH2O are sufficient. Individual titration of pressure should be performed based on Spo2 and respiratory distress. Fio2 is increased to 1.0 just before endoscopy and titrated to maintain Spo2 > 95%.

It should be acknowledged that due to loss of surfactant and inflammation ventilation / perfusion mismatch may last up to 12 – 24 hours after lavage. In general, we would continue noninvasive ventilation for at least 30 minutes after the end of bronchoscopy to allow recruitment of lung tissue. Support and Fio2 are tapered guided by Spo2. In some patients support by noninvasive ventilation may be necessary for more than 12 hours after bronchoscopy.

6. Endoscopy

From practical perspective bronchoscopy during noninvasive ventilation is not different from unassisted endoscopy. Both oral and nasal introduction of the bronchoscope is possible, but in general oral introduction is easier due to the position of the orifice for the bronchoscope in the interface (figure 1, 3).

Adverse events

Bronchoscopy in hypoxemic patients should be considered as a high-risk procedure. Although noninvasive ventilation decreases the risks, in particular oxygen desaturation, clinicians should be well prepared for any adverse events, related to bronchoscopy or noninvasive ventilation. Gastric hyperinflation increases the risk of aspiration and should be reduced by maintaining low inspiratory pressures, whenever possible. When hypoxemia develops despite increase in PEEP and Fio2, the procedure should be discontinued immediately. If severe or persistent hypoxemia occurs, endotracheal intubation should be performed. Cardiac complications are rare and mostly secondary to the development of hypoxemia.

It should be acknowledged that clinically relevant complications are uncommon with appropriate patient selection. In our clinic, patients with rather severe hypoxemia are deemed appropriate for bronchoscopy during noninvasive ventilation, but only under meticulous monitoring of peripheral oxygen saturation and heart rhythm, in the presence of a clinician trained for emergency endotracheal intubation.

Role for noninvasive ventilation in other endoscopic procedures?

The clinical experience regarding NIV to facilitate endoscopic procedures other than bronchoscopy is rather limited. Very few studies have been reported in the literature. We will therefore discuss this issue in less detail.
Severe orthopnea in cardiac disease patients may increase the risks associated with transesophageal ultrasound as this usually requires the patient to be in supine or lateral position. NIV has been used to facilitate transesophageal ultrasound, for instance during percutaneous aortic valve replacement. Due to the relatively large diameter of the ultrasound endoscope, the commercially available elbows (figure 2) cannot be used. However, with a surgical cutter a vertical hole can be made in the soft part of the interface that allows leak free introduction of the endoscope. Very recently interfaces have been introduced that allows introduction of large diameter endoscopes (figure 4a). Moreover, one type even allows application after the endoscope has been introduced (figure 4b). In general, some level of sedation will required during the procedure. We would prefer remifentanil due to its short half life and favourable hemodynamic characteristics. Close monitoring of vital signs is required in these high risk patients.

Prolonged endoscopic procedures in gastroenterology such as endoscopic retrograde cholangiopancreatography (ERCP) usually require the use of sedatives. This may increase the risk of pulmonary complications in particular in patients with respiratory muscle weakness, COPD, obesity and heart failure. Despite absence of high quality studies, the use of NIV during ERCP should be considered in these patients. Although some experts have advocated the use of nasal interfaces for NIV with ERCP, the efficiency will be limited due to air leak with mouth opening. New types of interfaces allow introduction of ERCP endoscope while using a full face mask (figure 4). Vital signs of the patient should be monitored closely during the procedure. Likewise, NIV should be considered to facilitate percutaneous endoscopic gastrostomy (PEG) in high risk patients, in particular patients with severe respiratory muscle weakness such as amyotrophic lateral sclerosis. Although the use of nasal masks has been advocated, the new full face masks (figure 4) are probably superior, due to reduced air leak. However, as clinical experience is limited this should be performed only by professionals with considerable experience in both NIV and endoscopy and under close monitoring of vital signs.

Legends to the figures

Figure 1
Full face mask modified for the use of bronchoscopy during non-invasive ventilation. A synthetic cylinder was secured in the mask. A disposable cap (from a swivel connector) sealed the cylinder and prevented air leakage during bronchoscopy

Figure 2
Commercially available elbow connector that allows introduction of the bronchoscope during noninvasive ventilation, when this connector is placed between interface and ventilator tubing. (A) Side view, (B) front view.

Figure 3
Oral introduction of the flexible video-bronchoscope through the dedicated commercially available elbow. Written permission for publication of the photo was obtained from the patient.

Figure 4
A. Example of interface with large orifice that allow the introduction of all diameter endoscopes, including such as used with transesophageal ultrasound or endoscopic retrograde cholangiopancreticography (VBM Endoscopy mask, Sulz, Germany, photo used with permission). B. Interface with large orifice that can be applied after oral introduction of the endoscope (Biomedical, Florance, Italy. Photo used with permission).
REFERENCES