Journal of Clinical Anesthesia (2016) **34**, 420–426

ELSEVIER

Journal of Clinical Anesthesia

**Original contribution**

# Noninvasive ventilation during spontaneous breathing anesthesia: an observational study using electrical impedance tomography☆,☆☆

**Julien Bordes MD*, Philippe Goutorbe MD, Pierre Julien Cungi MD, Marie Caroline Boghossian MD, Eric Kaiser MD (Professor)**

*Department of Anesthesia and Intensive Care, Sainte Anne Military Teaching Hospital, Toulon, France*

Received 28 November 2014; revised 21 March 2016; accepted 7 April 2016

**Keywords:**
Noninvasive ventilation;
Anesthesia;
Electrical impedance tomography

**Abstract**

**Study Objective:** To assess the effects of noninvasive ventilation (NIV) during spontaneous breathing anesthesia on functional residual capacity and ventilation distribution.

**Design:** Prospective and observational study.

**Setting:** Operating room, military teaching hospital.

**Patients:** Eighteen adult patients submitted to digestive endoscopic procedures under spontaneous breathing anesthesia.

**Interventions:** Anesthetic management was standardized. Patients were submitted to combined digestive endoscopic procedures (gastric fibroscopy and colonoscopy) under spontaneous breathing anesthesia in lateral decubitus position. Anesthesia was induced with propofol intravenous 1 mg/kg. Repeated boluses of propofol were administered according to the patients' clinical needs during endoscopic procedures. Ventilation distribution and functional residual capacity were assessed by electrical impedance tomography.

**Measurements:** Ventilation distribution was assessed by electrical impedance changes in left and right lung, and functional residual capacity changes were evaluated by measurement of end-expiratory lung impedance changes. Measures were performed before anesthesia induction, 5 minutes after anesthesia induction during gastric fibroscopy, at the end of gastric fibroscopy, 5 minutes after NIV application during colonoscopy, and at the end of colonoscopy.

**Main Results:** In awake patients, tidal volume was primarily distributed to the dependent lung (57.5% vs 43.1%; $P = .009$). After anesthesia induction, we observed a shift of ventilation to the nondependent lung (43.1% before anesthesia, 58.9% after anesthesia; $P = .002$) and marked decrease in end-expiratory lung impedancemetry of −1.68UI (4.47). Noninvasive ventilation application resulted in a significant increase of end-expiratory lung impedancemetry of 1.33 (6.49) ($P = .005$) but did not impact ventilation distribution.

**Conclusions:** This study showed that NIV application in pressure support mode during spontaneous breathing anesthesia increased functional residual capacity. Other studies are needed to evaluate the clinical impact of this technique during anesthesia, especially in patients with poor respiratory conditions.



☆ Funding information: No funding sources.

☆☆ The authors have no conflict of interest to declare.

* Correspondence: Julien Bordes, Département d'Anesthésie et de Reanimation, Hôpital d'Instruction des Armées Sainte Anne, Boulevard Sainte Anne, 83000 Toulon, France. Tel.: +33 483162385; fax: +33 483162743.

*E-mail address:* bordes.julien@neuf.fr (J. Bordes).

http://dx.doi.org/10.1016/j.jclinane.2016.04.016
0952-8180/

## 1. Introduction

Spontaneous breathing (SB) general anesthesia is common practice during short procedures. In France, SB anesthesia represents more than half of all anesthesia [1]. However, hypoxemia can occur during this type of anesthesia. In a series of 186 patients submitted to endoscopic retrograde cholangiopancreatography, desaturation ($SpO_2$ <92%) was found in 40% of patients [2]. Hypoxemia may be due to effects of analgesic and sedative drugs on respiratory function. Indeed, anesthetic agents have has been shown to increase airway resistance and to decrease response to hypercapnia, leading to decrease in tidal volume and minute ventilation [3,4]. These effects promote atelectasis and cause decrease in functional residual capacity (FRC) [5].

Use of noninvasive ventilation (NIV) in the postoperative period has been shown to improve gas exchange, decrease work of breathing, and reduce atelectasis [6]. Its application to prevent or to treat postoperative acute respiratory failure has been reported to be useful, with a better response with pressure support ventilation (PSV) + positive end-expiratory pressure (PEEP) compared with continuous positive airway pressure alone [6,7]. PSV is a ventilator mode recently available in anesthesia ventilators. Use of NIV in anesthesia has been reported during the preoxygenation phase in obese patients to enhance oxygenation before intubation [8,9] and also in the intraoperative period in 3 settings [10]: therapeutic to treat an established perioperative acute respiratory failure, prophylactic in patients with chronic severe respiratory limitations, and prophylactic in sedated healthy patients to avoid hypoventilation due to anesthesia [11–18]. Effects of spontaneous breathing during general anesthesia were assessed by comparing the ventilation distribution in 30 nonobese patients enrolled in a randomized trial [19]. SB was shown to prevent redistribution of ventilation toward the ventral region when compared to pressure-controlled ventilation and pressure support ventilation. However, a laryngeal mask airway was used in this study, and to date, the effects of NIV on respiratory function during SB general anesthesia have never been documented.

Electrical impedance tomography (EIT) is a noninvasive, radiation-free tool for the assessment of regional lung ventilation at the bedside and in the operating room. The EIT device measures the impedances between a series of electrodes placed around the chest in a transversal section of thorax. Correlations have been demonstrated between changes in end-expiratory lung impedance (EELI) and changes in end-expiratory lung volume, which is equivalent to FRC in nonintubated patients [20,21].

The aim of our study was to assess the effects of NIV during SB anesthesia on ventilation distribution and FRC using EIT device.

## 2. Materials and methods

This observational study was approved by Sainte Anne local ethics committee. Adult patients (> 18 years old) who were scheduled for gastrointestinal endoscopy associating gastric fibroscopy and colonoscopy were screened by the anesthesia team, and after successful screening, they were included in the study. The exclusion criteria were contraindications to SB anesthesia, known allergy to anesthetic drugs, and presence of a pacemaker or implantable cardioverter defibrillators. Written consent was obtained from all patients.

### 2.1. Anesthetic management

Patient did not receive premedication. After arrival in the operating room, they were monitored according to clinical standards (heart rate [HR], noninvasive blood pressure, and oxygen saturation). Anesthesia was induced with propofol 1 mg/kg. Repeated boluses of propofol were administered according to the patients' clinical needs (defined as patient movement) during endoscopic procedures. No morphinic agent was administered. At the end of the procedure, patients were transported to the postanesthesia care unit.

### 2.2. Study procedures

Three periods were defined.

In the first period (period 1), patient was installed in left lateral decubitus in the operating room.

In the second period (period 2), anesthesia induction was achieved as described, and then gastric fibroscopy was performed. During this period, patients remained breathing spontaneously, and oxygen was administered through a specifically designed device at a flow of 5 L/min.

In the third period (period 3), immediately after the gastric fibroscopy, NIV was started, and colonoscopy was performed. NIV was delivered through a mask held on the face to prevent air leaks. Anesthesia ventilator was used to perform NIV in PSV (Avance S/5, Datex ohmeda; General Electric Company, Fairfield, CT). Pressure support and PEEP were set at 8 cm $H_2O$ and 6 cm $H_2O$, respectively. The inspired concentration of $O_2$ was set at 100%.

### 2.3. Electrical impedance tomography measurement

EIT uses the electrical conductivity of chest to generate cross-sectional images of lung inferred from surface electrical measurements realized by a 16-electrode belt. In biological tissue, conductivity varies between tissues depending on air content. The electrodes are placed to the skin, and a few milliampere current is applied across 2 electrodes; other electrodes are used to measure resulting voltage.

In our study, EIT measurements were performed with the Pulmovista 500 tomograph (Dräger medical) (Fig. 1). The electrode belt was placed around the patients' chest between the fourth and the sixth intercostal spaces. The position of patient was left lateral decubitus and was not changed during the period of measurement.

The Pulmovista 500 tomograph measures impedance changes in real time. This device gives clinician information