# 39 Noninvasive Ventilation in Postoperative Patients

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## Contents



## Abbreviations

| | |
|---|---|
| ARF | Acute respiratory failure |
| BPAP | Bi-level positive airway pressure |
| CABG | Coronary artery bypass graft |
| CPAP | Continuous positive airway pressure |
| FRC | Functional residual capacity |
| HFNO | High-flow nasal oxygen |
| ICU | Intensive care unit |
| IMV | Intermittent mechanical ventilation |
| NIV | Noninvasive ventilation |
| OHS | Obesity hypoventilation syndrome |
| OSA | Obstructive sleep apnea |
| PPC | Postoperative pulmonary complications |
| RCT | Randomized control trial |

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## 39.1 Introduction

General anesthesia causes physiological changes after surgery. There is a decrease in muscle tone in the upper airway with decreased airway reflexes which, when coupled with a reduction in tidal volume and respiratory rate, leads to a reduction in the minute ventilation. This leads to hypercarbia and hypoxemia. Hypoxemia is exaggerated by a decrease in the functional residual capacity (FRC). This is also confounded by an increase in the closure of the small airways of the lung which leads to dead space and shunt. Noninvasive ventilation (NIV) is gaining popularity for both the treatment and prevention of acute respiratory failure (ARF) in postoperative patients [1]. Postoperative pulmonary complications (PPC) can also affect patients' outcome in terms of morbidity, mortality, and economic burden [2, 3]. Therefore, prevention of PPCs is essential. This chapter aims to consolidate current knowledge regarding NIV use in the postoperative period. We will focus

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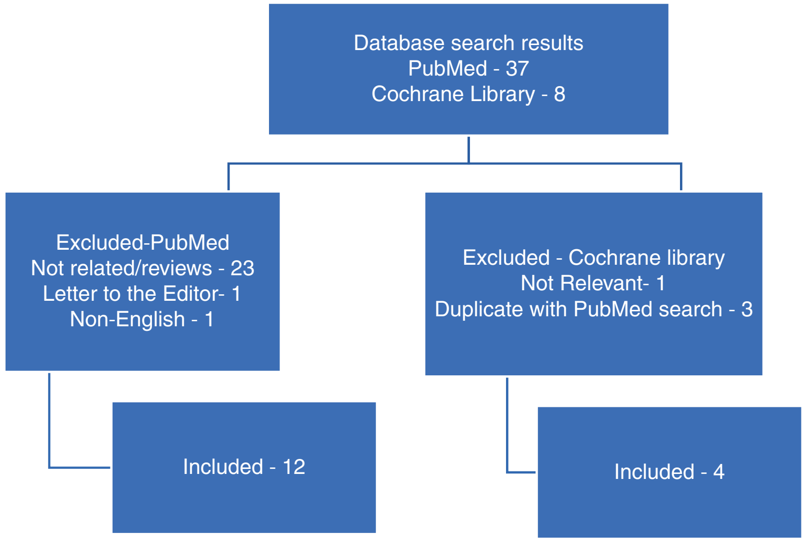


**Fig. 39.1** Literature search strategy

on NIV use after abdominal, thoracoabdominal, and cardiac surgeries.

Electronic databases including PubMed and the Cochrane library were searched to find recent literature related to noninvasive ventilation in the postoperative period. The index words "noninvasive ventilation," "postoperative," "noninvasive ventilation postabdominal surgery," "noninvasive ventilation post cardiac surgery," and "noninvasive ventilation post-thoracoabdominal surgery" were used. Published articles between January 2005 and March 2019 were of interest for review preparation. A systematic search for recent literature was done for the period of January 2017 to March 2019. Clinical studies, systematic reviews, and meta-analyses were included. Only studies in English were considered. The search strategy flow chart is presented in Fig. 39.1.

## 39.2 Content

Surgery can exacerbate the sequelae of anesthesia because of the involvement of the diaphragm and abdominal wall. Postoperative pulmonary complications are highest after abdominal surgery, the most common of which is respiratory failure. Postoperative respiratory failure is defined as the need for mechanical ventilation for more than 48 h after surgery or requiring mechanical ventilation after extubation. Abdominal surgery is associated with the highest rate of postoperative pulmonary complications with up to 50% of patients affected. Postoperative pulmonary complications are associated with longer hospital stays and higher inpatient mortality [3]. Noninvasive ventilation is an essential tool in the prevention and even management of postoperative respiratory failure, as well as other complications.

Several studies have evaluated NIV use as a prophylactic and therapeutic measure for postoperative respiratory failure in the abdominal surgical population. While NIV use has been shown to improve postoperative oxygenation, reduce intensive care unit length of stay, decrease the rates of pneumonia, reduce atelectasis, and reduce intubation rates, there have been no studies that show a definitive mortality benefit [4–6]. It is important to note that in patients undergoing bariatric surgery, in whom obstructive sleep apnea (OSA) and obesity hypoventilation syndrome (OHS) are highly prevalent, NIV use may actually have a mortality benefit [7]. Likewise, intensive care unit mortality as a result of postoperative respiratory failure after liver, kidney, and lung solid organ transplantation may be reduced with NIV use [8, 9]. The most relevant and recent trials targeting NIV use after abdominal surgery are summarized in Table 39.1.

**Table 39.1** Summary table of studies investigating noninvasive ventilation use after abdominal surgery

| Study authors, year | Study population | Intervention | Outcomes/considerations |
|---|---|---|---|
| Squadrone et al. (2005) [4] | * Randomized, controlled, unblinded<br>* Patients with hypoxemia after abdominal surgery | * Oxygen ($n$ = 104) versus Oxygen plus CPAP ($n$ = 105) | * Reduction in intubation rate, pneumonia incidence, infection, sepsis with $O_2$/CPAP use<br>* Reduced ICU length of stay; no effect on hospital length of stay with $O_2$/CPAP use |
| El Solh et al. (2006) [7] | * Prospective, single-center, case-control<br>* ICU patients, with BMI >35 kg/m$^2$ | * Conventional oxygen support versus NIV use immediately after successful weaning trial/extubation ($n$ = 62) | * 16% ARR in reintubation with NIV use<br>* Reduction in respiratory failure in hypercarbic obese patients with NIV use<br>* Shorter ICU and hospital lengths of stay in the NIV group<br>* Reduced mortality in the hypercarbic subgroup with NIV use<br>* BPAP ST and S modes used, starting IPAP/EPAP of 12/4 cm$H_2O$ (range IPAP 12–26, range EPAP 5–12)<br>* Mean use of BPAP was 16.2 ± 2.6 h/day |
| Glossop et al. (2012) [8] | * Meta-analysis; 16 randomized-controlled studies<br>* Varied (thoracic, abdominal thoracoabdominal, and solid transplant surgical populations) | * Three NIV cohorts: (1) NIV use in weaning; (2) NIV use in post-ICU extubation; (3) NIV use immediately post-surgery | * Reduced ICU length of stay, pneumonia, and reintubation rates with NIV use<br>* Increased hospital survival, not ICU survival, was noted with NIV use<br>* CPAP and other NIV modalities were grouped together |
| Ireland et al. (2014) [6] | * Meta-analysis, (Cochrane): ten studies; randomized control trials<br>* Elective or emergent major abdominal surgery | * Postoperative CPAP use as a preventative measure of major pulmonary complications and death after abdominal surgery | * Mortality benefit with CPAP use not determined because of study heterogeneity<br>* BPAP use was an exclusion criterion<br>* Reduction in atelectasis, pneumonia, and reintubation rates seen with CPAP use<br>* No reduction in severe hypoxemia with CPAP use |
| Das Faria et al. (2016) [5] | * Meta-analysis (Cochrane): two studies, randomized controlled trials<br>* Laparotomy cases<br>* Upper abdominal surgery | * Postoperative NIV (CPAP and BPAP) efficacy in acute respiratory failure as compared to conventional oxygen supplementation | * Reduction in intubation with NIV use<br>* Possible reduction in hospital length of stay with NIV use<br>* Inconclusive on whether NIV causes an anastomotic leak, reduces pneumonia-related complications and infections<br>* CPAP and BPAP |
| Jaber et al. (2016) [9] | * Multicenter, randomized, parallel-group clinical trial<br>  * Elective and emergency abdominal surgery cases<br>* Most laparotomies | * Oxygen therapy ($n$ = 150) versus NIV ($n$ = 150) in preventing reintubation within 7 days, decreasing 90-day mortality, infections, ventilation-free days, and gas exchange | * Reduced intubation, infection incidence with NIV use<br>* Trend toward lower mortality in the NIV group<br>* BPAP: IPAP 5–15 cm$H_2O$, EPAP 5–10 cm$H_2O$ |

Numerous studies have addressed NIV use in the cardiac and thoracoabdominal populations (see Table 39.2). The study conducted by Mamo found that the composite outcome of postoperative pulmonary complications and ICU admission was very low with postoperative NIV use as compared to standard management, i.e., 2% vs. 57%; *P* 0.002 [10]. Stephan, in a post hoc analysis of an RCT, comparing HFNO versus NIV, found no significant difference in ICU mortality between the groups, 5.9% vs. 2.2%, respectively; *P* 0.22 [11]. The same study also found that the treatment failure rate in the NIV group was 13.3% vs. 15.4% in the HFNO group; *P* 0.62 [11]. Yu Y, comparing HFNC and conventional face mask oxygenation, found a significantly decreased rate of reintubation and treatment failure in HFNO group as compared to traditional oxygen therapy ($P < 0.05$) [12].

Interestingly, in this study use of IMV, and CPAP, BiPAP was used as a rescue treatment even for HFNC. The study by Zochios examined

**Table 39.2** Summary table of studies investigating noninvasive ventilation use after thoracoabdominal surgery

| Study authors, year | Study population | Intervention | Outcomes/considerations |
|---|---|---|---|
| Mamo et al. (2019) [10] | 40 patients who underwent elective thoracoabdominal aortic surgery open repair | Prophylactic NIV | Prophylactic NIV prevents postoperative pulmonary complications |
| Marcondi et al. (2018) [17] | 100 postoperative coronary artery bypass graft patients with left ventricular dysfunction | Postoperative NIV for 1 h after extubation | Useful in improving central venous oxygen saturation and decreasing blood lactate level |
| Elgebaly et al. (2018) [14] | 44 postoperative cardiac surgical patients with acute respiratory failure | Therapeutic intermittent positive pressure ventilation versus NIV | NIV was safe and effective, but IPPV was superior to the NIV |
| Stephan et al. (2017) [11] | 271 postoperative cardiothoracic patients total with obesity | NIV versus high-flow nasal oxygen therapy | Although the failure rate was higher in HFNO, it was not statistically different |
| Yu et al. (2017) [12] | 110 postoperative thoracoscopic lobectomy patients | HFNO versus conventional oxygen therapy | HFNO improves oxygenation and reintubation rate |
| Olper et al. (2017) [16] | 64 post-cardiac surgical patients with hypoxemia in the ward | CPAP versus standard oxygen therapy | CPAP was associated with improved respiratory outcome |
| Cavalcanti et al. (2018) [15] | 50 obese adult postoperative Roux-en-Y gastric bypass patients | Preventive NIV versus control | NIV group had faster recovery, fewer postoperative complications |
| Zochios et al. (2018) [13] | 100 Adult patients with preexisting respiratory disease undergoing elective cardiac surgery | Prophylactic postoperative HFNO versus conventional oxygen therapy | HFNO reduced hospital stay and ICU readmissions |
| Ferrand et al. (2019) [18] | 91 neonates who underwent esophageal atresia-tracheoesophageal fistula repair | Postoperative NIV | NIV was associated with a significantly higher risk of anastomotic leak and mediastinitis |
| Pieczkoski et al. (2017) [20] | Systematic review and meta-analysis | Postoperative NIV in cardiac surgical patients | Prophylactic NIV did not significantly reduce the occurrence of pulmonary complications, reintubation rate, and ICU-LOS |
| Zhu et al. (2016) [21] | Systematic review and meta-analysis | Efficacy and safety of NIV in the cardiothoracic surgical population as compared to conventional management | Reduction in reintubation rates and improvement in oxygenation with NIV use |

the effect of prophylactic HFNC oxygenation as compared to standard oxygenation by face mask in postoperative cardiac surgical patients [13]. The authors found that there was a 29% reduction in the length of stay; *P* 0.004 [13]. Use of prophylactic HFNC oxygenation was also associated with decreased ICU readmission; *P* 0.026. However, the study by Elgebaly did not find a significant difference in hospital or ICU stay among the IMV versus NIV group [14]. The study by Cavalcanti et al. also found no difference in hospital and ICU stay and ICU stay after Roux-en-Y surgery between NIV and control group [15].

Elgebaly found that oxygenation ($PaO_2$ and $SpO_2$) and ventilation were better in the IMV group as compared to the NIV in cardiac patients [14]. Olper examined the efficacy of CPAP in improving hypoxemia in postoperative cardiac surgery patients as compared to standard treatment with oxygen supplementation with a face mask and found that the $PaO_2/FiO_2$ was better in the CPAP group; *P* 0.003 [16]. Yu investigated the effect of HFNC and conventional face mask oxygenation on reducing hypoxemia and PPC in postoperative thoracoscopic lobectomy surgery patients [12]. The authors found that $PaO_2$, $PaO_2/FiO_2$, and $SaO_2/FiO_2$ were significantly improved in HFNO group as compared to conventional oxygen therapy ($P < 0.05$). Marcondi applied NIV after extubation in postoperative CABG patients who had left ventricular dysfunction and compared with those who were spontaneously breathing and found that the central venous oxygen saturation was significantly higher in the NIV group (*P* 0.04), and this effect persisted even after discontinuation of NIV [17]. The authors also found that global perfusion as measured by serum lactate was also significantly better (*P* 0.008) with NIV in this group of patients.

The study by Cavalcanti et al. found that the spirometric respiratory parameters were better in obese patients using prophylactic NIV after Roux-en-Y surgery, especially on the first postoperative day [15]. Elgebaly AS including postoperative cardiac surgical patients did not find a significant difference in the complication rates among the IMV versus NIV group [14]. The study conducted by Stephan, however, found increased pressure-related skin breakdown in the NIV group as compared to the HFNO group; *P* 0.01 [11]. A retrospective chart review by Ferrand found that use of NIPPV was associated with increased risk of mediastinitis (*P* 0.005), and use of HFNC was associated with increased risk of anastomotic leak and mediastinitis in the patient who underwent esophageal atresia-tracheoesophageal fistula repair [18]. However, Cavalcanti found no significant increase in anastomotic ulcers in the NIV group as compared to the standard treatment group in patients who underwent Roux-en-Y surgery [15]. Postoperative complications such as pneumonia and atelectasis were significantly less in the NIV group in the same study. A recent case report also suggests the development of acute parotitis as a complication of postoperative NIV [19].

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