59 Use of Noninvasive Ventilation in Postoperative Patients in Abdominal Surgery

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Contents

Abbreviations

ARF	Acute respiratory failure
BIPAP	Bilevel positive airway pressure
COPD	Chronic obstructive pulmonary disease
COT	Conventional oxygen therapy
CPAP	Continuous positive airway pressure
EPAP	Expiratory positive airway pressure
HFNC	High flow nasal cannula
IPAP	Inspiratory positive airway pressure
NIPPV	Noninvasive positive pressure ventilation
NIV	Noninvasive ventilation
PEEP	Positive end-expiratory pressure
PPCs	Postoperative pulmonary complications

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59.1 Introduction

Noninvasive positive pressure ventilation (NIPPV) has become the standard for treating acute respiratory failure (ARF) in the intensive care unit [1, 2]. However, to date the role of the noninvasive ventilation (NIV) in patients with acute pulmonary complication after surgery is not defined. In general, 5–10% of all surgical patients develop postoperative respiratory failure and up to 40% of those who underwent abdominal surgery [3]. Jaber et al. [4] describe acute respiratory failure as a severe respiratory distress with dyspnoea, a respiratory rate of more than 25 breaths/min, contraction of accessory inspiratory muscles, paradoxical abdominal motion, peripheral oxygen saturation less than 92% while breathing at least 10 L/min of oxygen, or partial pressure of arterial oxygen (PaO_2) less than 60 mmHg on room air or less than 80 mmHg while breathing supplemental oxygen. The pathophysiological effects of anaesthesia and abdominal surgery on the respiratory system include prolonged lung volume reductions, diaphragm dysfunction, alveolar collapse and reduced mucociliary clearance. All of these increase the likelihood of development of postoperative ARF. Several strategies to maintain alveolar patency in such patients are available and may assist in postoperative pulmonary complications (PPCs) prevention. In addition to the NIPPV, other types of postextubation respiratory support have been proposed and compared for management of pulmonary complications and prevention of re-intubation [5]. Continuous positive airway pressure (CPAP) and high flow nasal cannula (HFNC) benefit hypoxaemic patients with acute peri-operative/peri-procedural respiratory failure [6]. Therefore, we can say that there is a universal agreement to the use of NIV, CPAP and HFNC for patients at high risk of re-intubation, but the specific circumstances in which each therapy should be used are unclear.

59.2 Current Evidence and Discussion

Several studies suggest a reduction in PPCs after high risk abdominal surgery may be achieved with use of postoperative NIV [6]. The definition of high risk has varied in the literature, but most clinicians would agree that patients with a history of chronic obstructive pulmonary disease (COPD) or congestive heart failure, body mass index >40 kg/m^2, age > 65 years, multiple spontaneous trial failures, excessive secretions and upper-airway obstruction meet the definition. Eighty patients, who had previously received a COPD diagnosis from a pulmonologist, undergoing elective abdominal surgery (hepatectomy, Whipple procedure, incisional hernia repair, splenectomy cholecystectomy, omentectomy and nephrectomy) were randomly allocated into four group to compare the effects of high/low- flow CPAP (Respironics BiPAP Vision device and flow generator HAROL, Italy), bilevel positive airway pressure (BIPAP) and spontaneous ventilation with oxygen support [7]. All patients were transferred to the recovery room following extubation. In the first group, prophylactic BIPAP was applied for 60 min with the parameters (with Respironics BIPAP Vision device), FiO_2 40%, IPAP (inspiratory positive airway pressure)

12 cmH_2O and EPAP (expiratory positive airway pressure) 5 cmH_2O; in the second group prophylactic CPAP was applied for 60 min with the parameters CPAP (flow generator HAROL, Italy), CPAP level 5 cmH_2O and FiO_2 40%; in the third group prophylactic CPAP was applied for 60 min with the parameters (with Respironics BIPAP Vision device) CPAP level 5 cmH_2O and FiO_2 40%; in the fourth group 6 L min^{-1} oxygen was applied with a face mask for 60 min, deep breathing exercises and respiratory physiotherapy were conducted on the patients. No statistically significant difference was found between the groups in terms of $PaCO_2$, PaO_2 and SpO_2. Nevertheless, the authors concluded that CPAP ventilation with a mechanical ventilator in high risk patients could be a valid prophylactic respiratory support. Jaber et al. [8] conducted a multicentre randomised clinical trial of NIV in surgical patients who developed hypoxemic acute respiratory failure after abdominal surgery. In accordance with the Declaration of Helsinki, the trial was conducted between May 2013 and September 2014 in 20 French intensive care units among 293 patients that were randomly assigned to receive standard oxygen therapy (up to 15 L/min to maintain SpO_2 of 94% or higher) or NIV delivered via facial mask (inspiratory pressure support level 5–15 cmH_2O; positive end-expiratory pressure 5–10 cmH_2O; fraction of inspired oxygen titrated to maintain $SpO_2 \geq 94\%$). Patients had undergone laparoscopic or non-laparoscopic elective or non-elective abdominal surgery under general anaesthesia. The outcomes were tracheal reintubation within 7 days following randomisation, gas exchange, health care-associated infections rate within 30 days, invasive ventilation-free days at day 30 and 90-day mortality. Noninvasive ventilation improved the primary outcome of the 293 patients included in the intention to treat analysis; reintubation occurred in 49 of 148 patients (33.1%) in the NIV group and 66 of 145 (45.5%) in the standard oxygen therapy group at 7 days after randomisation (absolute difference, −12.4%; 95% CI, −23.5% to −1.3%; $p = 0.03$). Noninvasive ventilation was associated with significantly more invasive ventilation-free days compared with standard oxygen therapy (25.4 vs. 23.2 days; absolute difference, −2.2 days; 95% CI, −0.1 to 4.6 days; $p = 0.04$), while fewer patients developed health care-associated infections (43/137 [31.4%] vs. 63/128 [49.2%]; absolute difference, −17.8%; 95% CI, −30.2% to −5.4%; $p = 0.003$). At 90 days, 22 of 148 patients (14.9%) in the NIV group and 31 of 144 (21.5%) in the standard oxygen therapy group had died (absolute difference, −6.5%; 95% CI, −16.0% to 3.0%; $p = 0.15$). The findings of the randomised clinical trial support use of NIV, because compared with standard oxygen therapy, it reduced the risk of tracheal reintubation within 7 days. Faria et al. [9] compared noninvasive positive pressure ventilation versus standard oxygen therapy in the treatment of acute respiratory failure after upper abdominal surgery. This review included two trials involving 269 participants [10, 11]. The authors concluded that CPAP or bilevel NIPPV is an effective and safe intervention for managing postoperative lung complications. They also reported that NIPPV may be considered in patients with acute respiratory failure after oesophageal surgery, when the insufflation pressure level was less than 12 cmH_2O. In 2019, a pilot study was conducted with 130 patients randomly assigned for usual care of continuous high-flow nasal oxygen therapy for 48 h following extubation or usual care plus additional early intermittent

NIV [12]. The eligibility for therapy was defined using the Melbourne Group Scale; PPCs is diagnosed when four or more of eight screening criteria are present in a 24-h day. Although NIV is well tolerated by most patients, it is not entirely free from serious adverse side effects. This randomised controlled trial clearly describes the NIV-complications. The absolute contraindications are cardiac or respiratory arrest, severe agitation or encephalopathy, untrained pneumothorax or intraoperative pneumothorax with intercostal catheter, uncontrolled vomiting, inability to protect airway, severe upper gastrointestinal or haemoptysis, need for immediate intubation and facial trauma. Anatomical leak and severe hypotension are the major adverse event. The problems related to interface–ventilator interaction during NIV and remedies, or arm oedema, CO_2 rebreathing, claustrophobia, discomfort, nasal skin lesions and noise, are reported extensively in the literature. High-flow nasal cannula has the distinct advantage over NIV and CPAP of being more comfortable and least likely to fail because of patient tolerance, but it should not be the choice of therapy when specific and high levels of PPEP are required or when ventilation is needed. CPAP and HFNC have been advocated for the treatment of hypoxemic respiratory failure; however, if the failure is a result of atelectasis, then CPAP is again the therapy of choice because PEEP (positive end-expiratory pressure) is indicated and can be applied at a precise level. Patients who are hypercarbic require ventilation, hence NIV is indicated. In patients with hypoxemia who require either CPAP or HFNC, the choice is dependent on the need for precise and high PEEP levels. The OPERA (Optiflow for prevention of post-extubation hypoxemia after abdominal surgery) trial is the first randomised controlled study powered to investigate whether early application of HFNC following extubation after abdominal surgery prevents against postoperative hypoxemia and pulmonary complications [13]. High-flow nasal cannula oxygen delivers a flow-dependent positive airway pressure and improves oxygenation by increasing end-expiratory lung volume. This ventilatory support, which delivers high-flow heated and humidified oxygen and air via nasal prongs at a prescribed fraction of inspired oxygen and a maximum flow of 60 L/min, is an attractive alternative to conventional oxygen therapy. Between 6 November 2013 and 1 March 2015, 220 patients were randomly assigned to receive either HFNC (n = 108) or standard oxygen therapy (n = 112). Participants were provided with high-flow nasal oxygen therapy postoperatively for a median duration of 15 (IQR 12–18) h following extubation. HFNC oxygen therapy is delivered via the Optiflow™ system (Fisher & Paykel Healthcare Ltd., Auckland, New Zealand) using an MR850 heated humidifier and an RT202 breathing circuit. The primary endpoint was absolute risk reduction for hypoxaemia at 1 h after extubation and after treatment discontinuation. Secondary outcomes included occurrence of postoperative pulmonary complications within 7 days after surgery, the duration of hospital stay and in-hospital mortality. Although prophylactic use of HFNC may have potential therapeutic advantages over conventional oxygen therapy for respiratory support after extubation, evaluation is limited in the early post-extubation surgical period and benefit remains to be established. No difference in the absolute risk reduction of postoperative hypoxaemia 1 h after extubation [21% vs. 24%, absolute risk reduction −3 (95% CI −14 to 8)%, P 1/4 0.62] were reported. Several

confounding factors, such as postoperative pain management, intraoperative fluid administration and respiratory chest physiotherapy, can be suggested. The authors concluded that the routine use of postoperative HFNC after extubation does not seem to be justified in similar patients. A single French study used the FreeO_2 system (Oxynov, Quebec, Canada) in the post-anaesthesia care unit in a patient population admitted for major abdominal and thoracic surgery [14]. FreeO_2 is an innovative device for treatment of hypoxemia during the immediate postoperative period. The system, using artificial intelligence closed-loop adjustments and predictive analytics, can perform frequent and rapid O_2 variations. FreeO_2 is equipped with a SpO_2 monitor and an electronically controlled valve that automatically adjusts O_2 flow from 0 to 20 L/min on a per-second basis, with a 0.1 L/min precision, according to a closed-loop algorithm to reach the predetermined SpO_2 target. Primary outcome is the percentage of time spent in the target zone of oxygen saturation during a 3-day time frame. The target zone of oxygen saturation is SpO_2 = 88–92% for patients with COPD and 92–96% for patients without COPD. Automated O_2 administration is not the standard of care for postoperative patients. Although this study supports the FreeO_2 system, more quality studies are needed to confirm these findings. The European Respiratory Society/America Thoracic Society clinical practice guidelines recommends the use of NIV and/or CPAP for patients with postoperative ARF6. No guidelines recommended the use of any of these therapies in patients at low risk of re- intubation. Leone et al. [15] reported the guidelines that The European Society of Anaesthesiology and European Society if Intensive Care Medicine developed for the use of NIV in the hypoxaemic patient after surgery. Among 19 recommendations, the two grade 1B recommendations state that: in the peri-operative/peri-procedural hypoxaemic patient, the use of either NIPPV or CPAP is preferred to COT for improvement of oxygenation; and that the panel suggest using NIPPV or CPAP immediately post-extubation for Hypoxaemic patients at risk of developing acute respiratory failure after abdominal surgery. The expert panel outlined five clinical questions regarding treatment with noninvasive respiratory support techniques: What goals of therapy? Which patient populations? What monitoring, laboratory, radiological tests during treatment? Prevention complications? Location of care? Specifically, after upper abdominal surgery for hypoxaemic patients, the authors suggest CPAP or NIPPV rather than COT (conventional oxygen therapy) to reduce the risk of hospital-acquired pneumonia and its associated complications, with level of evidence 2A. In general, the first query determined the target of therapy with NIV and the panel concluded either NIPPV or CPAP to improve oxygenation, to prevent the risk of reintubation, to reduce the mortality rate, as compared with COT in the surgical patients with acute respiratory failure. The second query identified patients may benefit from the use NIPPV or CPAP. With level 1B the noninvasive support is suggested immediately post estimation for hypoxaemic patients after abdominal surgery. Periodic clinical assessment, continuous monitoring (pulse oximetry, noninvasive blood pressure, electrocardiography) and periodic sampling for partial gas pressures were recommended based on indirect evidence. Semirecumbent positioning in patients at risk of aspiration, helmet versus face mask are tips to keep in mind. No recommendation regarding the location of care is in

these guidelines due to the scarcity to date. The authors also highlight the gaps in the evidence, in particular, no information regarding surgical complications in perioperative patients. NIV with high pressures has traditionally been contraindicated after major gastric and oesophageal surgery due to the theoretical risk of gastric dilatation and disruption of surgical anastomoses.

59.3 Conclusion

Abdominal surgery is most often followed by diaphragmatic dysfunction and a marked decrease in vital capacity, which often leads to respiratory failure or massive atelectasis. Mechanical ventilation with reintubation is necessary when any of the following major criteria or three or more of the minor criteria are met. Major criteria are: respiratory arrest, respiratory pauses with loss of consciousness or gasping respiration, encephalopathy and cardiovascular instability. Intolerance or discomfort to NIV, a decrease in PaO_2, or $PaCO_2$ by 20% or more, an increase in the respiratory rate, difficulty in removing airway secretions are minor criteria that must always be kept in mind. Certainly, NIV is an efficacy treatment for pulmonary complications. This result should, however, be interpreted with caution [16].The ability to anticipate and to provide early treatment to potentially modifiable adverse clinical events such as postoperative hypoxemia is of critical importance to prevent the development of subsequent complications. In surgical patients, the choice between NIV,CPAP or HFNC is influenced by the PEEP levels needed. HFNC is an appropriate alternative to NIV in patients who do not need high levels of PEEP. Patient compliance is absolutely essential and the most determining factor of success or failure of noninvasive ventilation. Our findings support the use of NIPPV for management of ARF after surgery. As enthusiastic supporters of using NIV in postoperative patients, we acknowledge that one of the greatest barriers to its more widespread application is the uncertainty that exists over which mode of support should be used in which patients. Future studies should investigate developing a specific protocol for patients at high risk for ARF.

Key Recommendations

- Post operative pulmonary complications following surgery are common and associated with increased morbidity and mortality and hospital length of stay
- Incision site pain, residual anaesthetic effect, abdominal surgery and lying position decrease lung compliance and cause lung atelectasis and diaphragm dysfunction
- NIPPV can be effectively used in the first-line intervention for treatment and prevention of ARF following abdominal surgery. NIPPV reduces the risk of reintubation
- HFNC should be considered in the management of post-extubation respiratory failure after surgery

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