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EDITORIAL

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Preventive or curative postoperative noninvasive ventilation after thoracic surgery: still a grey zone?

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Thoracic surgery procedures and anesthesia result in reduced lung volumes, respiratory muscle dysfunction and atelectasis. Thoracic surgery procedures are at high risk of developing postoperative pulmonary complications related to the characteristics of the patients, who are often COPD, and surgical aggression. The main respiratory modifications after thoracic surgery mostly lead to atelectasis, hypoxemia, acute respiratory failure (ARF), pneumonia, or bronchopulmonary fistula, with a high mortality rate. Postoperative noninvasive ventilation (NIV) may be a helpful additional symptomatic treatment in these patients after surgery (Table 1). It has been suggested [1] that there are two potential goals of NIV in the post-operative period (Fig. 1): (1) to prevent ARF (prophylactic treatment), or (2) to treat ARF and avoid reintubation (curative treatment).

To date, only one RCT [2] has been performed in hypoxemic ARF after thoracic surgery using NIV as curative strategy. Auriant et al. [2] randomized 48 patients with ARF after lung resection surgery to NIV ($n = 24$) or standard therapy ($n = 24$). Despite the small sample size, there was a significant decrease in the need for reintubation in the NIV group versus standard group (who did not receive NIV) (50 vs. 21 %, $p < 0.05$) and also a significant reduction in mortality (37.5 vs. 12.5 %, $p < 0.05$).

The prophylactic use of NIV before and after lung surgery in COPD patients has been shown to accelerate recovery of lung function, with a trend towards reduced incidence of atelectasis and hospital length of stay [3]. Perrin et al. [3] evaluated the use of NIV prophylactically administered in the pre- and post-operative periods. Patients followed standard treatment without or with NIV for 7 days at home before surgery and during 3 days postoperatively. Oxygenation was significantly better in the NIV group for the first three postoperative days, and hospital stay was significantly shorter for the NIV group.

In an observational prospective survey, Lefebvre et al. [4] evaluated the feasibility and efficacy of early NIV in subjects with acute respiratory failure following lung resection surgery. The overall success rate of NIV was 85 %. Riviere et al. [5] reported the following variables associated with NIV failure following lung surgery: tachypnea, higher Sequential Organ Failure Assessment score, number of bronchoscopies performed, and number of hours spent on NIV. Nevertheless, the clinical benefit of prophylactic NIV after thoracic surgery in COPD patients remains unclear.

In this issue of *Intensive Care Medicine*, Lorut et al. [6] report a large prospective randomized trial performed in seven thoracic surgery departments, aiming to investigate whether systematic postoperative NIV may prevent respiratory complications following lung resection surgery in COPD patients. In this multicenter study, 349 COPD patients undergoing lung resection surgery were randomly assigned to 2 groups: conventional

Table 1 Main studies using postoperative noninvasive ventilation after thoracic surgery

Authors	Year	Type of surgery	Study design	Patients	NIV mode	Interface	Main results
Preventive							
Aguilo [7]	1997	Pulmonary	Physiological	$n = 20$ 2 groups	SB PSV+10-PEEP+5	Nasal	Oxygenation improvement
Kindgen-Miles [8]	2005	Thoraco-abdominal	Prospective, randomized	$n = 50$ 2 groups	SB CPAP+10	Nasal	Oxygenation improvement, hospital stay decrease
Perrin [3]	2007	Pulmonary	Prospective, Randomized (before and after surgery)	$n = 34$ 2 groups	SB PSV+10-PEEP+5	Nasal	Oxygenation improvement, hospital stay decrease
Lorut [6]	2013	Pulmonary (COPD)	Prospective, randomized	$n = 360$ 2 groups	SB PSV+10-PEEP+5	Facial	No significant difference in acute respiratory events
Curative							
Kindgen-Miles [9]	2000	Thoraco-abdominal	Prospective, observational	$n = 20$	CPAP+10	Nasal	Oxygenation improvement,
Antonelli [10]	2000	Thoracic and abdominal (liver transplant, renal, lung)	Prospective, randomized	$n = 40$ 2 groups	SB PSV+15-PEEP+6	Facial	Intubation and mortality decrease
Rocco [11]	2001	Pulmonary (transplant)	Retrospective, observational	$n = 21$	PSV+14-PEEP+5	Facial	Feasability, safety. Oxygenation improvement
Auriant [2]	2001	Pulmonary	Prospective, randomized	$n = 48$ 2 groups	SB PSV+9-PEEP+4	Nasal	Intubation and mortality decrease
Lefebvre [4]	2009	Pulmonary	Prospective, observational	$n = 113$	PSV+14-PEEP+5	Facial	Feasability, safety, overall success rate of NIV 85 %
Riviere [5]	2010	Pulmonary	Retrospective, observational	$n = 130$	PSV+14-PEEP+5	Facial	Feasability, safety, overall success rate of NIV 70 %

SB spontaneous breathing, *CPAP* continuous positive airway pressure, *PSV* pressure support ventilation, *PEEP* positive end expiratory pressure

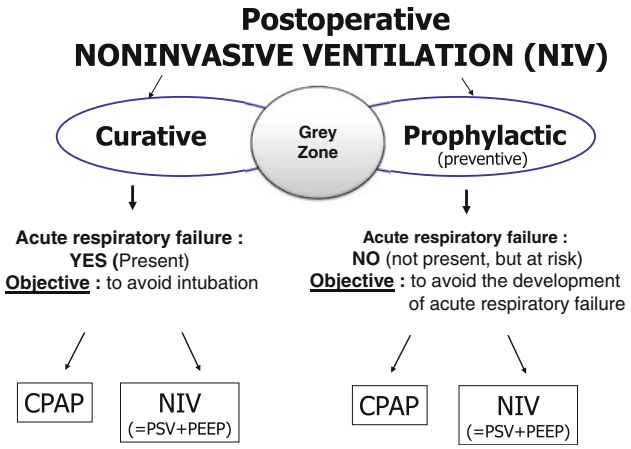

Fig. 1 The two main strategy approaches for applying postoperative noninvasive ventilation (NIV, i.e., two positive pressure levels). Usually, there are two potential goals of NIV in the postoperative period: (1) to prevent acute respiratory failure (prophylactic treatment), or (2) to treat acute respiratory failure and avoid reintubation (curative treatment). It is sometimes difficult to clearly separate "preventive" to "curative" application of NIV. Probably, part of the patients received NIV for a "grey zone" indication (at the time of start of NIV and also after) which may be considered as an intermediary state between both "preventive" and "curative" application of NIV. *CPAP* continuous positive airway pressure (one positive pressure level), *PSV* pressure support ventilation, *PEEP* positive end expiratory pressure

postoperative treatment without ($n = 174$) or with ($n = 175$) NIV. NIV was delivered either through a facial (Philips, Performatrack, Respironics) or nasal mask (Philips, Profile, Respironics) and was intermittently applied for 6 h per day for 48 h following surgery. The primary endpoint was the rate of acute respiratory events (ARE) at 30 days postoperatively. ARF was defined as the presence and persistence of at least two of the following: respiratory acidosis (arterial pH $<$ 7.35 together with $PaCO_2$ $>$50 mmHg); arterial O_2 saturation by pulse-oximetry of $<$90 % or PaO_2 lower than 60 mmHg at FiO_2 of 0.5 or nasal oxygen therapy at 8 l/min; respiratory rate $>$30 breaths per min; clinical signs of ARF, i.e. cyanosis, sweats, involvement of accessory respiratory muscles, paradoxical abdominal motion, consciousness impairment. For patients allocated to the prophylactic NIV group, rescue therapy consisted of reinstitution or continuation of NIV beyond the scheduled time. Secondary endpoints were ARF, use of rescue NIV, reintubation rate, infectious and non-infectious complications, duration of ICU and hospital stay, and mortality rate. The ARE rates were not statistically different in the NIV and control groups (50/175, 28.6 % vs. 55/174, 31.6 % $p = 0.54$). ARF rate was 19.4 % in the NIV group and 25.8 % in the controls ($p = 0.19$). Rescue NIV use was significantly lower in the NIV group (27/175, 15.4 % vs. 42/175, 25.4 %, $p = 0.05$) but re-intubation rates were not statistically different between the groups (10/175 (5.7 %) and 13/174 (7.5 %), respectively, in the NIV and control groups, $p = 0.53$). Mortality rates were, respectively, 5.3 and 2.3 % in the control and NIV groups ($p = 0.17$). Infectious and non-infectious complication rates, and duration of ICU and hospital stays, were not different between groups. Lorut et al. [6] have made an important contribution to the continually evolving research into the use of NIV in the management of patients after planned thoracic surgery, especially in COPD. Their results extend the suggestions of other authors that NIV should be considered and applied in selected patients in a modern ICU. Moreover, their findings are consistent with those of other research addressing the relationship between the level of healthcare staffing and patients' general outcomes. Not only the ventilator or interface used and the selected appropriate patients but also the skills and expertise of both medical and nonmedical personnel represent some of the most important factors for the success of NIV.

The authors concluded that preventive postoperative NIV did not reduce the rate of ARE in COPD patients undergoing lung resection surgery, but decreased the need for rescue NIV for ARF without influencing other postoperative complications rates, mortality rates, and duration of ICU and hospital stay [6].

This randomized controlled study [6] may be considered as a "negative" study because it did not demonstrate that early prophylactic NIV after major lung resection surgery in patients with moderate-to-very severe COPD (GOLD II to IV) is able to decrease the rate of ARE. The authors reported several hypotheses that may explain these "negative" results. The end points used (somehow arbitrarily) in this trial to measure the benefit of preventive NIV merit comment. ARE is a composite endpoint that included clinical, biological, and radiological signs of pulmonary complications. Re-intubation rate was rather low with NIV (5.5 %). This confirms once again that, in patients with ARF after lung resection surgery, NIV is able to avoid intubation in many cases. This point suggests that preventive NIV could be more effective in better selected severe patients at risk in future studies. The selection of the appropriate patients who may benefit from postoperative preventive NIV is a key issue. Another hypothesis relates to NIV application methods. Prophylactic NIV was not applied immediately after extubation, as the mean time between extubation and NIV initiation was more than 4 h; this could have decreased its efficacy. Part of the negative results may be explained by the discrepancies in skills and expertise of both medical and nonmedical personnel of the participant centers.

Finally, in the postoperative period, it is sometimes difficult to clearly separate "preventive" from "curative" application of NIV. Probably, part of the patients received NIV for a "grey zone" indication (at the time of start NIV and also after), which may be considered as an intermediary state between both "preventive" and "curative" application of NIV. Further studies are needed to better

identify the patients who may benefit of NIV after thoracic surgery and the optimal NIV protocol delivered (duration, interfaces, settings, etc.).

Conflicts of interest Dr. Jaber reports receiving consulting fees from Dräger, Hamilton, Maquet and Fisher Paykel. Dr. Antonelli reports receiving research grants from Orion Pharma and Dräger and consulting fees from Fisher Paykel, Pfizer and Cubist.

References

1. Jaber S, Chanques G, Jung B (2010) Postoperative noninvasive ventilation. Anesthesiology 2:453–461
2. Auriant I, Jallot A, Herve P, Cerrina J, Le Roy Ladurie F, Fournier JL, Lescot B, Parquin F (2001) Noninvasive ventilation reduces mortality in acute respiratory failure following lung resection. Am J Respir Crit Care Med 164:1231–1235
3. Perrin C, Jullien V, Venissac N, Berthier F, Padovani B, Guillot F, Coussement A, Mouroux J (2007) Prophylactic use of noninvasive ventilation in patients undergoing lung resectional surgery. Respir Med 101:1572–1578
4. Lefebvre A, Lorut C, Alifano M, Dermine H, Roche N, Gauzit R, Regnard JF, Huchon G, Rabbat A (2009) Noninvasive ventilation for acute respiratory failure after lung resection: an observational study. Intensive Care Med 35:663–670
5. Riviere S, Monconduit J, Zarka V, Massabie P, Boulet S, Dartevelle P, Stephan F (2011) Failure of noninvasive ventilation after lung surgery: a comprehensive analysis of incidence and possible risk factors. Eur J Cardiothorac Surg 39:769–776
6. Lorut C, Lefebvre A, Planquette B, Quinquis L, Clavier H, Santelmo N, Hanna HA, Bellenot F, Regnard JF, Riquet M, Magdeleinat P, Meyer G, Roche N, Huchon G, Coste J, Rabbat A (2013) Early postoperative prophylactic noninvasive ventilation after major lung resection in COPD patients: a randomized controlled trial. Intensive Care Med. doi: 10.1007/s00134-013-3150-2
7. Aguilo R, Togores B, Pons S, Rubi M, Barbe F, Agusti AG (1997) Noninvasive ventilatory support after lung resectional surgery. Chest 112:117–121
8. Kindgen-Milles D, Muller E, Buhl R, Bohner H, Ritter D, Sandmann W, Tarnow J (2005) Nasal-continuous positive airway pressure reduces pulmonary morbidity and length of hospital stay following thoracoabdominal aortic surgery. Chest 128:821–828
9. Kindgen-Milles D, Buhl R, Gabriel A, Bohner H, Muller E (2000) Nasal continuous positive airway pressure. A method to avoid endotracheal reintubation in postoperative high-risk patients with severe nonhypercapnic oxygenation failure. Chest 117:1106–1111
10. Antonelli M, Conti G, Bufi M, Costa M, Lappa A, Rocco M, Gasparetto A, Meduri G (2000) Noninvasive ventilation for treatment of acute respiratory failure in patients undergoing solid organ transpantation. A randomized trial. JAMA 283:235–241
11. Rocco M, Conti G, Antonelli M, Bufi M, Costa MG, Alampi D, Ruberto F, Stazi GV, Pietropaoli A (2001) Noninvasive pressure support ventilation in patients with acute respiratory failure after bilatéral lung transplantation. Intensive Care Med 27:1622–1626