Peer reviewed article

Non-invasive ventilation in the recovery room for post-operative respiratory failure: a feasibility study

Anne Battisti[a], *Jean-Bernard Michotte*[b], *Didier Tassaux*[a,c], *Elisabeth van Gessel*[c], *Philippe Jolliet*[a]

[a] Division of Medical Intensive Care, Cantonal University Hospital, Geneva, Switzerland
[b] Division of Physiotherapy, Cantonal University Hospital, Geneva, Switzerland
[c] Division of Anesthesiology, Cantonal University Hospital, Geneva, Switzerland

Summary

Background: Non-invasive ventilation (NIV) has become a standard of care in acute respiratory failure. However, little data is available on its usefulness in recovery ward patients after general surgery. The present study aimed to document the feasibility of implementing NIV in this setting, and its impact on lung function.

Methods: During a 12-month period, all adult patients who underwent elective general surgical procedures under general anaesthesia during weekdays, were transferred to the recovery ward after extubation, and those who required NIV were included in this prospective observational study. NIV was applied with a bilevel device (VPAP II ST, ResMed, North Ryde, Australia).

Results: 4622 patients were admitted to the recovery ward, 83 of whom needed NIV. NIV increased pH (7.38 ± .06 *vs* 7.30 ± .05), reduced $PaCO_2$ (7.38 ± .06 *vs* 7.30 ± .05) in hypercapnic patients (44 ± 9 *vs* 55 ± 10 mm Hg), and increased PaO_2 in non-hypercapnic patients (80 ± 10 *vs* 70 ± 11 mm Hg). No complications attributable to NIV occurred. Most patients improved after 1–2 NIV trials, and all were transferred to the ward the same day.

Conclusions: In recovery ward patients after general surgery, NIV is seldom required. When applied, NIV seems to exert favourable effects on lung function. NIV can be safely implemented with a bilevel device in a recovery ward not accustomed to the use of ICU ventilators. The cost-effectiveness of its systematic use in this setting should be assessed.

Key words: mechanical ventilation; non-invasive ventilation; post-operative; acute respiratory failure; bilevel devices

Introduction

During the last decade, non-invasive ventilation (NIV) has proven to be an effective strategy to reduce intubations rate, intensive care unit (ICU) and hospital lengths of stay, morbidity and mortality in patients with either hypercapnic [1] or non-hypercapnic [2] acute respiratory failure. NIV has thus become a standard of care in the management of these patients [3, 4]. Beneficial effects of NIV have also been documented in post-operative patients. Indeed, surgery can induce respiratory muscle dysfunction, which in turn can lead to hypoventilation, hypoxemia, atelectasis and infections [5]. Acute respiratory failure is one of the major complications of the early post-operative period [6]. NIV, performed in the intensive or intermediate care unit, has been shown to improve pulmonary function and gas exchange in patients after gastroplasty [7], lung resection surgery [8], and coronary artery bypass grafting [9]. However, little data have been published so far on the use of this technique outside of these specialised units after general surgery. Indeed, many such patients undergo a relatively brief stay in the recovery ward before being transferred to the general surgical ward. Recovery wards are often not equipped with intensive care ventilators, and nursing or physiotherapy staff is not trained in their use. We recently introduced NIV in our recovery ward, performed with a bilevel ventilator, and conducted a one-year prospective observational study to test the feasibility of the technique, quantify the need for its use, and evaluate its impact on pulmonary function. The present paper summarizes the results of that study.

No financial support declared.

Patients and methods

Patients

The study was approved by the Department of Anaesthesiology's clinical investigation committee, and was in accordance with the modalities of the Helsinki Declaration. During a 12-month study period, all adult patients who underwent elective general surgical procedures under general anaesthesia during weekdays, were transferred to the recovery room after extubation, and those who required non-invasive ventilator support were included in this prospective observational study. The need for NIV was established by the physician in charge of the patient in the recovery room, based on our usual practice guidelines. A physician is constantly present in the recovery room. The guidelines recommend NIV when signs of respiratory failure are present (respiratory rate >25/min. or <10/min., and hypoxemia with arterial partial pressure of oxygen/inspired oxygen fraction ratio (PaO_2/FIO_2) <300 and/or arterial partial pressure of carbon dioxide ($PaCO_2$) ≥45 mm Hg), after ensuring of adequate analgesia and airway secretion clearance. Briefly, the evaluation algorithm calls for pulmonary auscultation and an arterial blood gas analysis to be performed if the respiratory rate is >25/min. or <10/min., followed by a chest X-ray if PaO_2/FIO_2 <300, or if abnormal breath sounds are present. If signs of atelectasis are present on the chest X-ray, NIV is initiated even if the PaO_2/FIO_2 is >300.

On the basis of the blood gas analysis, two groups of patients were defined: "non-hypercapnic" ($PaCO_2$ <45 mm Hg), and "hypercapnic" ($PaCO_2$ ≥45 mm Hg). Exclusion criteria were: emergency surgery, transfer to the surgical ICU, tension pneumothorax, or any other classical contraindication to NIV (eg facial lesions, impaired consciousness, poor patient cooperation, haemodynamic instability) [3].

Non-invasive ventilation protocol

The choice between continuous positive airway pressure (CPAP) or pressure support was made according to current recommendations of opting for the former in non-hypercapnic and the latter in hypercapnic respiratory failure [3, 4]. NIV was applied by a trained respiratory therapist. Our recovery room is not equipped with high-end, multi-ventilator mode ICU ventilators based on proportional solenoid valve technology [10]. Therefore, NIV was applied with a bilevel turbine-type device, the VPAP II ST (ResMed, North Ryde, Australia), which can be used either in CPAP or pressure support mode. CPAP was initiated with a positive end-expiratory pressure of 5 cmH_2O. Pressure support was initially set at 10 cmH_2O inspirator pressure and 5 cmH_2O positive end-expiratory pressure (PEEP). Both modes were subsequently titrated according to patient tolerance, pulse oxymetry oxygen saturation (SpO_2) and respiratory rate. A backup rate ("ST" mode on the VPAP II ST) was applied in those patients in whom initial respiratory rate was <10/min. The target duration of the initial NIV trial was 45 min. Mean arterial blood pressure, respiratory and heart rates, dyspnea assessed by a visual analogue scale, and arterial blood gases were collected before, at the end (while still on NIV), and 30 minutes after this initial trial. Subsequently, NIV was applied if the initial criteria for its application were again met. Despite NIV, endotracheal intubation was performed if the following commonly accepted criteria [11] used routinely in our clinical guidelines [12], were met. *Major criteria:* respiratory arrest, loss of consciousness, severe agitation, haemodynamic instability (systolic blood pressure <70 mm Hg or >180 mm Hg, heart rate <50/min.). *Minor criteria:* respiratory rate >35/min. and higher than admission value, arterial pH <7.30 and lower than admission value, PaO_2 <45 mm Hg despite oxygen supplementation, neurological deterioration, weak cough reflex with secretion accumulation. Intubation was performed if one major or two minor criteria were present [11, 12]. If intubation was required, or if the patient's condition was judged too unstable for same-day ward transfer, the patient was transferred to the surgical ICU.

Results

During the study period, 4622 patients were transferred to the recovery room following elective surgical procedures, 83 of whom required NIV. Of those 83 most underwent thoracic, cardiovascular or abdominal surgery (table 1). The main clinical characteristics of the patients having received NIV are summarised in table 2. The male/female ratio was 47/36. More than 50 % of patients had a history of a chronic respiratory condition, obstructive disease being the most preva-

Table 1

Type of surgical procedure and incidence of non-invasive ventilation (NIV).

Type of surgery	n (% total)	n NIV (% group total)
Cardiovascular[a]	212 (4.5)	16 (7.5)
Minor vascular[b]	460 (10.0)	0
Thoracic	185 (4.0)	18 (9.7)
Abdominal	1350 (33.1)	34 (2.5)
Orthopedic	1275 (27.5)	10 (0.8)
Urologic	890 (19.2)	3 (0.3)
Neurologic	190 (4.1)	2 (1.1)
Other	60 (1.3)	0
Total	4622	83 (1.8)

Abbreviations: n NIV: number and % of patients in a given surgery group having received NIV;
[a] Excluding coronary artery bypass and valvular surgery;
[b] mostly peripheral vascular surgery, eg saphenous ligature.

Table 2

NIV indications and modalities in the two patient groups. Values reported as median (IQR).

	Non-hypercapnic	Hypercapnic
Number of patients	60	23
Age	70 (60–76)	69 (59–75)
Body mass index (kg/m^2)	26 (23–30)	25 (22–28)
Prior respiratory condition (n patients)		
Obstructive	28	10
Restrictive	4	1
Obstructive/restrictive	2	1
None	26	11
Indication for NIV (n indications)		
Altered arterial blood gases	26	17
Atelectasis on chest X-ray	25	0
Signs of fluid overload	10	0
Low respiratory rate	0	6
Type of NIV used (n instances)		
CPAP	46	0
Pressure support	11	13
Pressure support S/T	1	12

Table 3

Results of the initial application of NIV.

		Baseline	End NIV	30 min. post-NIV	
RR n/min.	non-hypercapnic	15 (11–18)	14 (12–18)	14 (10–19)	
	hypercapnic	10 (8–14)	14 (12–15)	13 (11–14)	
HR n/min.	non-hypercapnic	86 (74–97)	84 (72–98)	81 (72–98)	
	hypercapnic	89 (75–100)	83 (70–95)	83 (69–95)	
MAP mm Hg	non-hypercapnic	89 (75–104)	88 (79–100)	88 (78–98)	
	hypercapnic	77 (71–97)	77 (73–86)	78 (71–88)	
Dyspnea score VAS	non-hypercapnic	0 (0–1.5)	0 (0–1)	0 (0–1)	
	hypercapnic	0 (0–0.2)	0 (0–0.3)	0 (0–0.3)	
FIO_2	non-hypercapnic	.35 (.32–.39)	.35 (.33–.38)	.33 (.28–.37)	
	hypercapnic	.34 (.30–.37)	.31 (.29–.34)	.35 (0.31–.38)	
pH	non-hypercapnic	7.43 (7.39–7.45)	7.44 (7.40–7.47)	7.43 (7.39–7.46)	
	hypercapnic	7.33 (7.31–7.37)	7.37 (7.33–7.42)	7.35 (7.32–7.36)	
PaO_2 mm Hg	non-hypercapnic	70 (58–82)	80 (71–92)	74 (62–89)	
	hypercapnic	80 (71–103)	83 (77–100)	86 (79–109)	
SaO_2 %	non-hypercapnic	92 (90–96)	96 (94–98)	95 (93–97)	
	hypercapnic	93 (91–96)	96 (94–98)	96 (94–98)	
$PaCO_2$ mm Hg	non-hypercapnic	40 (36–42)	39 (36–40)	40 (37–41)	
	hypercapnic	55 (49–62)	44 (39–51)	45 (41–54)	

Abbreviations: HR: heart rate; FIO_2: inspired O_2 fraction; MAP: mean systemic arterial pressure; PaO_2: arterial O_2 partial pressure; $PaCO_2$: arterial CO_2 partial pressure; RR: respiratory rate; SaO_2: arterial O_2 saturation; VAS: visual analog scale, from 0–10 (0 = no dyspnea, 10 = worst possible dyspnea).
Values median (IQR).

lent. The last documented 1 s forced expiratory volume / forced vital capacity ratio (FEV 1.0/FVC) in this group was 58 ± 9% (mean ± SD). Following the criteria defined above, of the 83 NIV patients, 60 (72%) were non-hypercapnic and 23 (28%) hypercapnic. The predominant indications for NIV were altered blood gases and signs of atelectasis on the chest X-ray (table 2). Non-hypercapnic patients received mostly CPAP, hypercapnic patients being treated with pressure support with or without the backup rate. Table 3 summarises the main clinical, haemodynamic and gas exchange parameters at baseline, during the initial NIV application and 30 min. after it was discontinued. Very little change in these variables was noted, except for respiratory rate, which was lower in the hypercapnic group and increased with NIV. NIV also lowered $PaCO_2$ and increased pH in the hypercapnic patients, and improved arterial oxygenation in the non-hypercapnic ones. In 55 patients (66%), only one application of NIV was necessary. Twenty-eight patients (34%) required a

second NIV trial within two hours after the first. No complications were noted during NIV. Leaks around the mask occurred in 35 (42%) patients, but were not severe enough to interfere with the proper administration of the technique. No patient required either intubation or transfer to the ICU. All patients were transferred to the ward the same day.

Discussion

To summarise, the results of this study show that NIV with a bilevel device can be safely applied to patients in the recovery room after elective surgery under general anaesthesia. Moreover, it seems to improve gas exchange without the need for repeated trials and/or its prolonged application.

Before discussing these results further, some of the limitations of the study should be emphasised. First, this was not a randomised prospective trial, nor a controlled study. Therefore no firm conclusion can be drawn regarding the role of NIV in avoiding re-intubation in the post-operative setting. Nonetheless, none of the 83 patients had to be re-intubated, and one can hypothesise that NIV might have contributed to this outcome in at least some patients. Second, the study excluded patients undergoing emergency or major cardiac surgery, as well as those who were transferred directly from the operating room to the ICU. Therefore, our study population was skewed towards more stable patients, as reflected by the low incidence of need for NIV. This was partly due to institutional organisation constraints, since our recovery room only manages patients who have already been extubated, and are expected to stay for <24 hours before ward transfer. However, respiratory problems do still occur in this population, as shown by the present study. Third, NIV was applied by a trained respiratory therapist. In our recovery room, respiratory therapists are on call to apply NIV. However, this is clearly not the case in many institutions. Therefore our findings that NIV can be applied safely in this setting must be extrapolated with caution; proper training and experience are prerequisites for the safe application of NIV, wherever it is used.

Several studies have documented the favourable effects of NIV in acute respiratory failure, most having observed that numerous trials of NIV were often required, at times uninterrupted for several hours, before weaning was possible [1, 2, 13]. The post-operative setting is different; respiratory failure after successful extubation often stems from causes such as shallow breathing-induced atelectatic lesions, which result from diaphragmatic function impairment or pain, anaesthetic and/or analgesic drugs-induced hypoventilation, and/or peri-operative fluid overload [5, 7–9]. Contrary to the mechanisms underlying acute respiratory failure in the classical studies on NIV, most of these factors are usually rapidly reversible in this context. This probably explains why in two-thirds of the patients only one application of the technique was sufficient, and why the remaining one-third responded favourably to one or two additional trials. Supporting this assumption is the fact that the rapidly favourable outcome was also present in those patients with a history of prior respiratory disease.

Another notable difference is the very low dyspnea score of the patients, given that dyspnea is usually a prominent finding in acute or acute on chronic respiratory failure [14]. This most likely resulted from the analgesic medication that these patients had received, in particular opiates, which are known to effectively decrease dyspnea [15].

NIV can be performed with either an ICU ventilator or a bilevel pressure support device. Compared to the latter, the former is more powerful, exhibits more adjustable features (eg trigger type and sensitivity, pressurisation slope, cycling criteria) and provides extensive monitoring and alarm capabilities [16]. However, it is usually not available outside the ICU, and has a steep learning curve, especially for non-ICU staff. An alternative is to use bilevel-type devices. Indeed, such ventilators, whose performance has improved in recent years [10, 17, 18] are easier to use, take up less space, and are considerably less costly. These characteristics have made them an interesting option in the treatment of patients with moderately severe respiratory failure [19].

Conclusion

In conclusion, the present feasibility study shows that a brief application of NIV with a bilevel device can be safely applied in the recovery room to patients following general surgery, and presenting signs of respiratory failure. It also demonstrates that the incidence of acute respiratory failure is very low in this patient population. Therefore, trials should now be performed to explore whether the beneficial pathophysiological effects of NIV can have a favourable impact on the outcome of post-operative patients with signs of respiratory insufficiency.

Correspondence:
Dr. Philippe Jolliet
Service des soins intensifs de Médecine
Hôpital Cantonal Universitaire
CH-1211 Geneva 14
E-Mail: jolliet@medecine.unige.ch

References

1 Brochard L, Mancebo J, Wysocki M, Lofaso F, Conti G, Rauss A, et al. Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. N Engl J Med 1995;333: 817–22.
2 Ferrer M, Esquinas A, Leon M, Gonzalez G, Alarcon A, Torres A. Noninvasive ventilation in severe hypoxemic respiratory failure. Am J Respir Crit Car Med 2003;168:1438–44.
3 British Thoracic Society Standards of Care Committee. Noninvasive ventilation in acute respiratory failure. Thorax 2002;57: 192–211.
4 Liesching T, Kwok H, Hill N. Acute applications of noninvasive positive pressure ventilation. Chest 2003;124:699–713.
5 Siafakas N, Mitrouska I, Bouros D, Georgopoulos D. Surgery and the respiratory muscles. Thorax 1999;54:458–65.
6 Thompson J, Baxter T, Allison J, Johnson F, Lee K, Park W. Temporal patterns of postoperative complications. Arch Surg 2003;138:596–603.
7 Joris J, Sottiaux T, Chiche J, Desaive C, Lamy M. Effect of bilevel positive airway pressure (BiPAP) nasal ventilation on the postoperative pulmonary restrictive syndrome in obese patients undergoing gastroplasty. Chest 1997;111:665–70.
8 Aguilo R, Togores B, Pons S, Rubi M, Barbé F, Agutsi A. Noninvasive ventilatory support after lung resection surgery. Chest 1997;112:117–21.
9 Matte P, Jacquet L, Van Dyck M, Geoenen M. Effects of conventional physiotherapy, continuous positive airway pressure and non-invasive ventilatory support with bilevel positive airway pressure after coronary artery bypass grafting. Acta Anesthesiol Scand 2000;44:75–81.
10 Richard JC, Carlucci A, Breton L, Langlais N, Jaber S, Maggiore S, et al. Bench testing of pressure support ventilation with three different generations of ventilators. Intensive Care Med 2002;28:1049–57.
11 Nava S, Ambrosino N, Clini E, Prato M, Orlando G, Vitacca M, et al. Noninvasive mechanical ventilation in the weaning of patients with respiratory failure due to chronic obstructive pulmonary disease. A randomized, controlled trial. Ann Intern Med 1998;128:721–8.
12 Jolliet P, Abajo B, Pasquina P, Chevrolet J. Non-invasive pressure support ventilation in severe community-acquired pneumonia. Intensive Care Med 2001;27:812–21.
13 Paus-Jenssen E, Reid J, Cockroft D, Laframboise K, Ward H. The use of noninvasive ventilation in acute respiratory failure at a tertiary care center. Chest 2004;126:165–72.
14 Bott J, Carroll M, Conway J, Keilty S, Ward E, Brown A, et al. A randomized-controlled study of nasal intermittent positive pressure ventilation in acute exacerbations of chronic obstructive airways disease. Lancet 1993;341:1555–7.
15 Abernethy A, Currow D, Frith P, Fazekas B, McHugh A, Bui C. Randomised, double blind, placebo controlled crossover trial of sustained release morphine for the management of refractory dyspnoea. BMJ 2003;327:523–8.
16 Lofaso F, Brochard L, Hang T, Lorino H, Harf A, Isabey D. Home versus intensive care pressure support devices. Experimental and clinical comparison. Am J Respir Crit Care Med 1996;153:1591–9.
17 Tassaux D, Strasser S, Fonseca S, Dalmas E, Jolliet P. Comparative bench study of triggering, pressurization and cycling between the home ventilator VPAPII® and three ICU ventilators. Intensive Care Med 2002;28:1254–61.
18 Bunburaphong T, Imanaka H, Nishimura M, Hess D, Kacmarek R. Performance characteristics of bilevel pressure ventilators: a lung model study. Chest 1997;111:1050–60.
19 Plant P, Owen J, Elliott M. Early use of non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicentre randomised controlled trial. Lancet 2000;355:1931–5.

Swiss
Medical Weekly

Official journal of
the Swiss Society of Infectious disease
the Swiss Society of Internal Medicine
the Swiss Respiratory Society

The many reasons why you should choose SMW to publish your research

What Swiss Medical Weekly has to offer:

- SMW's impact factor has been steadily rising, to the current 1.537
- Open access to the publication via the Internet, therefore wide audience and impact
- Rapid listing in Medline
- LinkOut-button from PubMed with link to the full text website http://www.smw.ch (direct link from each SMW record in PubMed)

- No-nonsense submission – you submit a single copy of your manuscript by e-mail attachment
- Peer review based on a broad spectrum of international academic referees
- Assistance of our professional statistician for every article with statistical analyses

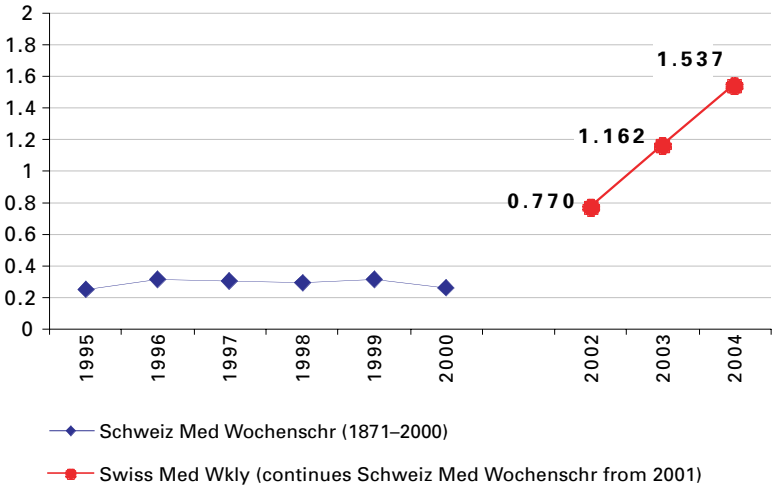
- Fast peer review, by e-mail exchange with the referees
- Prompt decisions based on weekly conferences of the Editorial Board
- Prompt notification on the status of your manuscript by e-mail
- Professional English copy editing
- No page charges and attractive colour offprints at no extra cost

We evaluate manuscripts of broad clinical interest from all specialities, including experimental medicine and clinical investigation.

We look forward to receiving your paper!

Guidelines for authors:
http://www.smw.ch/set_authors.html

Impact factor Swiss Medical Weekly



EMH FMH Schwabe
Editores Medicorum Helveticorum

All manuscripts should be sent in electronic form, to:

EMH Swiss Medical Publishers Ltd.
SMW Editorial Secretariat
Farnsburgerstrasse 8
CH-4132 Muttenz

Manuscripts: submission@smw.ch
Letters to the editor: letters@smw.ch
Editorial Board: red@smw.ch
Internet: http://www.smw.ch