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BRIEF REPORT

Luca Cabrini
Cristina Idone
Sergio Colombo
Giacomo Monti
Pier Carlo Bergonzi
Giovanni Landoni
Davide Salaris
Carlo Leggieri
Giorgio Torri

Medical emergency team and non-invasive ventilation outside ICU for acute respiratory failure

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L. Cabrini · C. Idone · S. Colombo · G. Monti · P. C. Bergonzi (✉) · G. Landoni · D. Salaris · C. Leggieri · G. Torri
Anesthesia and Intensive Care, San Raffaele Hospital and Scientific Institute, Via Olgettina, 60, 20132 Milan, Italy
e-mail: bergonzi.piercarlo@hsr.it
Tel.: +39-02-26433737
Fax: +39-02-26432200

Abstract *Objective:* To report data about "real-life" treatments with non-invasive ventilation for acute respiratory failure (ARF), managed outside intensive care units by anaesthesiologists acting as a medical emergency team. *Design:* Observational study; prospectively collected data over a 6-month period in a single centre. *Setting:* Non-intensive wards in a University Hospital with 1,100 beds. *Patients:* Consecutive patients with ARF for whom a ventilatory support was indicated but tracheal intubation was not appropriated or immediately needed. *Interventions:* None. *Measurements and results:* Patient's characteristics, safety data, short-term outcome and organizational aspects of 129 consecutive treatments were collected. The overall success rate was 77.5%, while 10.1% were intubated and 12.4% died (all of them were "do not attempt resuscitation" patients). The incidence of treatment failure varied greatly among different diseases. Complications were limited to nasal decubitus (5%), failure to accomplish the prescribed ventilatory program (12%), malfunction of the ventilator (2%) and excessive air leaks from face mask (2%) with no consequences for patients. Three patients became intolerant to NIV. The work-load for the MET was high but sustainable: on average NIV was applied to a new case every 34 h and more than three patients were simultaneously treated. *Conclusions:* Under the supervision of a MET, in our institution NIV could be applied in a wide variety of settings, outside the ICU, with a high success rate and with few complications.

Keywords Non-invasive ventilation · Acute respiratory failure (ARF) · Medical emergency team · Pneumonia · Cardiogenic pulmonary oedema · Chronic obstructive pulmonary disease

Introduction

Non-invasive ventilation (NIV) is an option in several types of acute respiratory failure (ARF) [1–4]. Many authors analysed NIV in intensive care units (ICU) [5–7], but few papers reported data about its clinical use outside ICU [8, 9]. NIV can be a resource for a medical emergency team (MET) [10].

We report the prospectively collected data over a 6-month period in a single centre, regarding NIV treatments outside ICU managed by a MET.

Materials and methods

The San Raffaele Hospital is a University Institute with 1,100 beds. Data collection took place from November 2005 to May 2006. The study was approved by the local Ethical Committee.

Patients did not receive NIV if one of the following exclusion criteria was present: cardiac arrest, hemodynamic instability, major arrhythmias, inability to manage secretions, undrained pneumothorax, not-hypercapnic coma, upper airway's obstruction, gastroesophageal bleeding or vomiting, recent gastroesophageal surgery, facial trauma, and inability of the patient to co-operate.

The main outcome of the study was the avoidance of tracheal intubation. Intubation was performed when the patient worsened as arterial blood gas (ABG) values, clinically (as respiratory distress or level of consciousness) despite NIV, or when NIV was contraindicated during treatment.

The MET shift was carried out only by anaesthesiologists, who in Italy work either in ICU or in theatres. The decision to prescribe NIV was reserved to the MET, always present in Hospital and trained on local guidelines (see online document); all health care personnel knew his beeper number and were authorized to call him. The MET was dedicated to critical patients in the Emergency Department (ED) or in the wards, and to the follow-up of patients in pre-critical conditions such as those on NIV. In most cases (in particular for patients in the ED or for acute pulmonary oedema) the onset of the respiratory failure was quick and the MET was called immediately, while in other cases with a slow onset (like pneumonia in surgical patients) the MET was called later.

Monitoring of patients was performed by the MET with the help of ward staff. Patients had heart rate, arterial pressure and pulsoxymetry monitored at least three times/day. ABG was always obtained before starting NIV and after 1–2 h of treatment. Hypoxic patients had a continuous pulsoxymetry monitoring. The MET planned the timing of his further visits (during which he could change the treatment parameters, or decide to intubate the patient, or stop NIV after improvement) and the frequency of monitoring and ABG. Taking into account patient's conditions and "do not attempt resuscitation" (DNAR) status, the MET evaluated if the patient could be treated safely in his the ward. Local guidelines allowed transferring patients to the ED or to the ICU for better monitoring.

Safety was assessed by recording the incidence of problems like nasal decubitus, aspiration pneumonia, malfunction of the ventilator, excessive air leaks from face-mask, disconnection of the oxygen tubing.

MET optimised medical and oxygen therapy first, and applied NIV after standard therapy failed, or immediately if needed for the severity of ARF.

CPAP was instituted when hypoxaemia prevailed and SaO_2 was <90% with a mask-reservoir; CPAP could also be applied to patients with severe respiratory distress even if SaO_2 was still ≥90%. CPAP was mostly used in cardiogenic pulmonary oedema, pneumonia, lung contusion, and postoperative atelectasis. Six portable machines for CPAP ("Vital-Flow 100", Vital-Signs, Totowa, NJ) were available in the study period. PEEP was ≥7.5 cm H_2O, O_2 fraction regulated to maintain SaO_2 ≥95%.

BiPAP was chosen when hypercapnia prevailed, or if associated with a pH <7.35; BiPAP was mostly used for COPD exacerbations and neuromuscular diseases. We used four portable "Vivo 40" (BREAS Medical AB, Mölnlycke, Sweden) and one "S/T-D 30", (Respironics, Murrysville, PA, USA). Since these ventilators do not allow delivering high O_2 fraction, they were not applied to seriously hypoxaemic patients. Expiratory positive airway pressure was set ≥5 cm H_2O; Inspiratory positive airway pressure was 15–20 cm H_2O, according to patient tolerance and respiratory rate; O_2 flow was set to maintain SaO_2 90–95%; the backup respiratory rate was set at 15 per min, in spontaneous/timed modality.

An initial continuous NIV (2–24 h) was followed by treatments of 1–2 h for 3–4 times/day. Humidification was not administered. Naso-gastric tubes were positioned only if gastric distension ensued. Nurse:patients ratios ranged from 1:2 in the Coronary Unit during day shifts to 1:20 in General Medicine and Orthopaedics during night shifts. The Coronary Unit was not considered an ICU, having no experience in NIV and a nurse:patients ratio of 1:4 during night.

Data were analysed by use of Epi Info 2002 software (CDC) and SAS software, version 8 (SAS Institute). Dichotomous data were compared by using two-tailed χ^2 test with the Yates correction or Fisher's exact test when appropriate. Continuous measures were compared by analysis of variance (ANOVA) or the Mann–Whitney U test when appropriate. Two sided significance tests were used throughout. Data are presented as mean (±SD) or number and percentage.

Results

Consecutive treatments were 129 in 129 patients, accounting for 25% of the overall 516 MET's interventions. No patient on NIV was transferred to ICU or to ED for a better monitoring in the study period.

Patients' characteristics and outcomes are reported in Table 1. The 16 (12%) patients who died during NIV treatment had all been judged DNAR cases.

NIV was performed in ten wards: ED (41% of cases, success rate 87%), General Medicine (27%, success rate 69%), General Surgery (6%), Orthopaedics (6%),

Table 1 Diagnosis, characteristics and outcomes of 129 consecutive patients receiving non invasive ventilation outside the intensive care unit over a 6 months period

Diagnosis	Number of patients (%)	Age	SAPSII	Treated by CPAP (%)	Baseline pO_2	Baseline pCO_2	Baseline pH	Baseline HCO_3^-	pO_2 after 1 h of NIV	pCO_2 after 1 h of NIV	pH after 1 h of NIV	HCO_3^- after 1 h of NIV	Favourable outcome (%)	Tracheal intubation (%)	Death (%)
Acute pulmonary oedema	45 (34)	73 ± 11.9	43 ± 9.1	62	69 ± 35.1	57 ± 18.5	7.26 ± 0.15	24 ± 5.4	119 ± 70.6*	48 ± 12.8*	7.36 ± 0.11*	25 ± 4.5	38 (84.4)	3 (6.7)	4 (8.9)
COPD exacerbation	34 (26)	76 ± 12	42 ± 10.4	0	72 ± 33.4	80 ± 21.5	7.25 ± 0.11	32 ± 6.3	74 ± 27.3	70 ± 20.4*	7.30 ± 0.10*	32 ± 6.2	32 (94.1)	2 (5.9)	0 (0)
Pneumonia	30 (23)	69 ± 15.8	46 ± 14	67	70 ± 33.3	48 ± 23	7.36 ± 0.13	25 ± 6.0	117 ± 74.4*	42 ± 15.7*	7.39 ± 0.11	25 ± 5.6	18 (60)	4 (13.3)	8 (26.7)
Neuromuscular Disease	6 (4)	71 ± 10.4	33 ± 4.9	0	81 ± 25.7	77 ± 19	7.26 ± 0.06	30 ± 4.6	108 ± 60.5	62 ± 19.2*	7.35 ± 0.09*	30 ± 5.2	2 (33.3)	2 (33.3)	2 (33.3)
Thoracic trauma	4 (3)	38 ± 9.7	20 ± 3.8	75	70 ± 20	51 ± 17.8	7.41 ± 0.07	26 ± 2.0	99 ± 22.8	43 ± 2.2	7.44 ± 0.03	27 ± 5.2	34 (100)	0 (0)	0 (0)
Postoperative hypercapnia	2 (2)	50 ± 0	50 ± 10.6	0	111 ± 63	78 ± 25.8	7.16 ± 0.21	24 ± 8.6	95 ± 31.8	58 ± 8.5	7.31 ± 0.15	25 ± 9.9	1 (50)	1 (50)	0 (0)
Hypoventilation in stroke	2 (2)	72 ± 2.8	32 ± 2.1	0	134 ± 11	81 ± 8.5	7.27 ± 0.16	33 ± 4.2	128 ± 75	60 ± 5.7	7.32 ± 0.08	29 ± 0.7	2 (100)	0 (0)	0 (0)
Neoplastic pleural effusion	2 (2)	73 ± 14.1	50 ± 12.7	100	58 ± 4.9	47 ± 7.6	7.35 ± 0.11	24 ± 5.7	77.2 ± 8.2	44 ± 2.9	7.34 ± 0.12	20 ± 0.0	0 (0)	0 (0)	2 (100)
Pulmonary fibrosis	2 (2)	85 ± 2.8	60 ± 2.8	50	43 ± 1.3	44 ± 31.8	7.31 ± 0.19	26 ± 11.5	106 ± 43.1	50 ± 31.8	7.34 ± 0.03	29 ± 0.0	1 (50)	1 (100)	0 (0)
Acute asthma	1 (1)	30	19	100	56	50	7.24	22	263	42	7.36	23	1 (100)	0 (0)	0 (0)
Postoperative atelectasis	1 (1)	77	39	100	63	37	7.44	25	73	58 ± 8.5	7.44	24	1 (100)	0 (0)	0 (0)
Sum	129 (100)	71 ± 14.8	43 ± 11.9	43	71 ± 35.1	62 ± 23.9	7,29 ± 0.14	27 ± 6.7	105 ± 62.6*	53 ± 19.3*	7.35 ± 0.11*	27 ± 6.2	100 (77.5)	13 (10.1)	16 (12.4)

Data are expressed as number (%) or mean ± standard deviation

* <0.05

SD standard deviation, *CPAP* continuous positive airway pressure, *NIV* non invasive ventilation, *COPD* chronic obstructive pulmonary disease

Coronary Unit (5%), Haematology (4%, with the worst outcomes: success rate 50%, mortality 33%), Cardiology (3%), Neurology (3%), Urology (1%), Vascular Surgery (1%). Patients were treated in their ward except 13 patients who needed tracheal intubation and were transferred to the ICU, and the 53 ED patients transferred to the appropriate ward (according to their disease and not to the NIV treatment on course). All ED patients were transferred to wards when they improved (all within 24 h); if NIV treatment was still in place at that time, the MET continued to monitor the patients as long as needed.

The workload for the MET (Table 2) included on average 3.2 ± 1.9 patients on NIV, (highest value: 9), and a new case every 34 h.

In seven cases (5%) we reported immediate failure: five patients were intubated, two DNAR cases died. Complications were limited to nasal decubitus (5%), failure to accomplish one period of the prescribed ventilatory program (12%), temporary ventilator malfunction (2%) and excessive air leaks from face-mask (2%), all without consequences for patients. Three patients became intolerant to NIV, all after 3 days of treatment; all of them had a favourable outcome. ABG improved quickly in most cases (Table 1) while patients were maintained on NIV for 4.7 ± 5.5 days.

Discussion

This is the first report giving a general picture on what are the indications, outcomes, and complications of NIV outside ICU in the "real life". We illustrated for the first time how NIV could be managed by a MET.

Guidelines [11, 12], reviews and meta-analyses [1, 3, 4, 13] about NIV mostly included studies performed in ICU. Recently, an increasing use outside ICU has been reported [14, 15]; sometimes in apparently inadequate setting with minimum monitoring, no protocols, and no specific training [16]. This trend can be explained by an increasing confidence with the technique, the shortage of ICU beds in many countries [9], and the opportunity to treat ARF in a more responsive phase [1]. However, effectiveness and safety must be verified in every setting [17].

Our study took place after a 10-year experience of NIV outside ICU. A long-lasting shortage of intensive beds forced us to violate the "best practice" recommendations [11, 12, 17].

In COPD exacerbations NIV should be a first-line of intervention in all suitable patients [3]. In our study NIV proved successful in more than 90% of patients. Other authors [9, 15, 18, 19] reported an incidence of failure between 15.9 to 45.4%. An elevated mean initial pO_2, suggesting previous injudicious O_2 therapy, could partially explain our higher success rate.

Table 2 Length of non invasive ventilation treatments outside the intensive care unit in 129 consecutive patients and number of medical emergency team visits

Diagnosis	Number of patients	Length of treatment in days	Number of MET visits in the first 24 h	Number of MET visits/day after the first 24 h
Acute pulmonary oedema	45	3.8 ± 5.4	3.1 ± 1.1	0.78 ± 0.64
COPD exacerbation	34	5.1 ± 5.4	3.3 ± 1.0	0.77 ± 0.46
Pneumonia	30	5.5 ± 6.7	2.9 ± 1.1	0.68 ± 0.52
Neuromuscolar Disease	6	4.8 ± 4.7	3.2 ± 0.8	0.55 ± 0.36
Thoracic trauma	4	4.5 ± 2.5	2.5 ± 0.6	0.81 ± 0.24
Postoperative hypercapnia	2	3.5 ± 3.5	3.0 ± 0.1	0.33 ± 0.0
Neoplastic pleural effusion	2	4.5 ± 0.7	3.0 ± 0.0	1.45 ± 0.07
Hypoventilation in stroke	2	4 ± 4.2	2.5 ± 0.7	0.79 ± 0.30
Pulmonary fibrosis	2	14 ± 0	3.0 ± 0.0	0.50 ± 0.00
Acute asthma	1	1	3.0	1.0
Postoperative atelectasis	1	2	1.0	1.0
Sum	129	4.7 ± 5.5	3.1 ± 1.0	0.76 ± 0.53

MET medical emergency team, *COPD* Chronic obstructive pulmonary disease

Acute pulmonary oedema was the most frequently treated disease, with a success rate of 84%. Success rates from 65 to 100% have been reported [1]. One single-centre study [20] and a multi-centric study [21] reported similar results.

Pneumonia showed a low percentage of favourable outcomes in our experience (60%), with results similar to those of other authors [21], confirming that if a non-invasive approach is chosen, a stricter monitoring or ICU admission must be considered [2].

Limitations

As in many cases we did not know the FiO_2 of the baseline (frequently obtained by ward staff) and of the second ABG, these data are not reported. We cannot provide information regarding the average daily time the MET spent in managing NIV. Theoretically, patients should have been transferred to areas devoted to ARF treatment, like Respiratory ICU. This did not happen in our experience because we lacked such areas. The ability to monitor patients outside the ICU varies markedly between institutions. Our report does not encourage unwarranted use of NIV outside ICU. Our MET has been introduced 18 years ago and the decision to perform NIV in general wards found an organised basis. Since efficacy and safety of NIV outside ICU are strongly dependent on hospital organization, a generalized adoption of the MET for performing NIV outside ICU cannot be recommended. What is effective in a hospital, can even be dangerous elsewhere. Furthermore, an excessive familiarity carries the risk of abusing of this technique [1]. The low mean number of follow-up visits that the MET was able to perform after the first 24 h (due to the high volume of activities he must daily perform) underlines the crucial role that the ward personnel plays in monitoring patients on NIV.

Conclusion

In our hospital, the MET applied NIV in a wide variety of settings outside the ICU (mainly COPD, cardiogenic pulmonary oedema, and pneumonia) with a high success rate and few complications. This experience may not be generalizable to other hospitals, and patients to be treated outside an ICU should be selected and monitored with caution.

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