Aging Clin Exp Res (2014) 26:615–623
DOI 10.1007/s40520-014-0223-1

ORIGINAL ARTICLE

Non-invasive ventilation for very old patients with limitations to respiratory care in half-open geriatric ward: experience on a consecutive cohort of patients

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Received: 21 December 2013 / Accepted: 8 April 2014 / Published online: 30 April 2014

Abstract
Introduction A leading role for non-invasive ventilation (NIV), as comfort treatment or palliative care, is actually recognized for very old patients suffering from ARF. NIV was frequently used in both ICU and respiratory ICU (RICUs) for very old patients and it is associated with a reduced rate of endotracheal intubations and mortality. This study aims to evaluate the effects of NIV, performed in a setting of half-open geriatric ward with family support, in a cohort of very old patients with ARF and DNI decision.
Methods A consecutive cohort of 20 very old patients with DNI decision was admitted in our 26-bed geriatric ward during a 6 months' period. DNI decision was obtained in emergency room with an intensive care physician supported by a psychologist. Pressure support ventilation was the first choice of NIV. NIV has been performed by three adequately trained geriatricians, with one of them experienced in ICU, and in close collaboration with intensive care physicians. Arterial blood gases, to assess the response to ventilation, were obtained after 1, 6 and 12 h. NIV settings were modified according to arterial blood gas analyses or respiratory fatigue, if needed.
Results Therefore, 75 % of patients were discharged home and 12 out of 20 patients had home respiratory support. PaO_2/FiO_2 ratio and pH increased while $PaCO_2$ decreased during the 12 h of NIV with statistical significance. At the admission, alive patients had $PaCO_2$ significantly lower than dead patients. After 12 h, alive patients had a better pH than dead patients. Dead patients experienced more complication than survivors.
Conclusion Very old DNI patients with ARF could be treated with NIV in half-open geriatric ward with trained physicians and nurses. The presence of family members may improve patients' comfort and reduce anxiety level even at the end of life. Further studies are needed to address the effective role of NIV in very old patients with DNI decisions.

Keywords Non-invasive ventilation · Half-open geriatric ward · Do not intubate · Very old patients · Respiratory care

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Introduction

The incidence of acute respiratory failure (ARF) increased exponentially with age [1]. Healthcare utilization especially admission in intensive care units for patients with acute exacerbations of COPD end ARF in developed countries was exponentially growing. These kind of patients have high rate of hospitalization (three to four times per year) [2–5]. Management of ARF for very old patients (age >80 years), due to their low survival rate, could consist of less use of invasive ventilation and less admission in intensive care unit (ICU) compared with

young, elderly patients (age <80 years) [6–8]. Patients aged 80 years may be candidate to the decision of "do not intubate" (DNI) that means the refuse endotracheal intubation to provide sustained assisted ventilation [9]. A leading role for non-invasive ventilation (NIV), as comfort treatment or palliative care, is actually recognized for very old patients suffering from ARF. In 2007 a population survey study investigated the health status of ARF in COPD patients in five European countries and US and reported that a significant but minority of European Union patients referred that their "health status was worse than death" because of significant impairment in physical daily activities, severe fatigue, pain and psychological morbidity due to anxiety and depressive symptoms [10]. NIV setting for very old fragile patients in which these psychological symptoms are more severe and with more severe associated comorbidities had a key role, given their high risk of developing life-threatening complications during invasive ventilation. Scala and Esquinas [11] and other authors suggested that DNI activities for very old patients with ARF, already ventilated at home with severe dependence in daily activities, should be placed in open or half-open place out of ICU. This issue could be important to reduce anxiety and depressive symptoms and to improve pain and psychological morbidity "related to DNI and end-of-life context". NIV was frequently used in both ICU and Respiratory ICU (RICUs) for very old patients [12–14] and it is associated to a reduced rate of endotracheal intubations and mortality [15].

NIV reduces the need for intubation and decreases mortality during acute-on-chronic respiratory failure (AOC), cardiogenic pulmonary edema (CPE), and de novo ARF in immunocompromised patients [16–20]. Recently, NIV has been proposed for the prevention of post-extubation ARF for at-risk patients, with promising results [21, 22]. Hospital survival rate in very old patients was similar to younger patients when NIV is applied in these validated indications. The choice of NIV aims to avoid complications, particularly in fragile patients [23].

This study aims to evaluate the effects of NIV, performed in a setting of half-open geriatric ward with family support, in a cohort of very old patients with ARF and DNI decision admitted from emergency room.

Methods

The study was conducted in Department of Geriatric diseases in the 26 bed geriatric ward of the San Giuseppe Moscati Hospital of Avellino. Written consent was obtained from patients or their surrogates. At the admission, APACHE III [24], activity of daily living (ADL), instrumental ADL (IADL) [25] and GCS [26], Comorbidities score index [27], were calculated for each patient included in the study. End stage chronic respiratory failure was defined according to the National Hospice Organization guidelines and included at least two criteria among: O_2 or NIV home treatment, previous ICU admission for ARF within the past years, FEV1 <30 % of predicted value or Cor pulmonale [28]. DNI decision was obtained in emergency room with an intensive care physician supported by a psychologist in charge of geriatric department. To all patients or to their surrogates was proposed the choice of endotracheal intubation (ETI). Reasons about anxiety and or/depression about admission in ICU and reasons about the patients' acceptance of alternative non invasive ventilation were checked by psychologist that elaborated a questionnaire administered through an accurate interview to family members and to patients themselves when possible.

Pressure support ventilation was the first choice of NIV set as follow: respiratory rate (RR) 12 breaths/min; pressure support (PS) 15 cm^2O, positive end expiratory pressure (PEEP) 5 cm H_2O, expiratory trigger setting (TE) 25–65 % (% of peak flow), depending from the underlining disease [29], pressure inspiratory trigger (IT)of 0.3–1.0 cm H_2O depending from patient's condition. Pressure support levels were set according to the patients' tolerance and to obtain target

An expired tidal volume of 6–8 ml/kg, while the external positive pressure was always $\leq$6 cm H_20. Oxygen supplementation was provided to reach a 90 % $\leq$ SaO_2 $\leq$ 94 % (FiO2 range from 25 to 45 %).

NIV was performed by three adequately trained geriatricians; one of these experienced in ICU decided the NIV setting in close collaboration with intensive care physicians. Arterial blood gases, to assess the response to NIV, were obtained after 1, 6 and 12 h. NIV settings were modified according to arterial blood gas analyses or respiratory fatigue, if needed. The other choice was continuous positive airway pressure (CPAP) with PEEP of 8–10 cm H_2O.

Adequately trained nurses participated to the management of NIV. The tasks of the nurses have been reported in the Appendix 1.

A physiotherapist in charge of the ward mobilized the patients twice a day. Family caregivers were present in the ward throughout the day with the particular task of administering the meals; other family members could visit patients at established visit time (4 h per day). Enteral or parenteral feedings were decided with nutritional specialist physicians. Pain management in cancer, COPD and neoplastic patients was decided with pain therapy specialist.

All figures involved in NIV treatment had two yearly training courses. The first training course is for all staff and was performed in hospital; the second training course is a theoretical, practical, educational course that includes the

Table 1 Characteristics and outcome of patients included in the study

Age	81.2 ± 9.3
Apache III	83.2 ± 3.8
Charlson comorbidity index	5.88 ± 3.53
ADL	3.5 ± 1.8
IADL	2.9 ± 2.7
Home MV before admission (*n*)	12/20
Length of stay in geriatric ward (days)	8.5 ± 3.8
Discharged *(n)*	15/20
Discharged with MV at home (*n*)	12/20
Died (*n*)	5/20

Data were reported as mean ± standard deviation

n number of patients, *MV* mechanical ventilation

Table 2 Psychologist's interview answers about reasons of acceptance of NIV and/or refusal admission in ICU

Family members/caregivers	
"The patient in his condition is too elderly to submit him to invasive procedures; if these are not avoidable we would came back home and refuse hospitalization"	5/20
"We would be able to keep on administering meals during break intervals of NIV"	10/20
"If it is possible for one family member stay night and day with patient if we accept NIV"	20/20
"To be able to allow the family members to make visit to the patient in a timeframe without excessive restriction"	20/20
Patients	
"Loss of Hope for admission in ICU"	12/20
"Lack of communication"; "not sure which doctor will be taking care of me and not sure about cardiopulmonary procedures"	5/20
"Unwillingness to discuss end of life care and allowed the choice to their relatives"	4/20
"I'm very tired and no more invasive procedures"	1/20

application of NIV, but also the basis of the cardio-respiratory reanimation and the management of the emergencies organized by Italian emergency medicine society (SIMEU—non invasive ventilation group) and/or organized by VAM group (mechanical non-invasive ventilation—Italian group). The training consists also in periodic reunions about the elaboration or implementation of protocols of NIV treatment and in participating to specific congresses.

Statistical analysis

Data have been reported as mean and standard deviation. Univariate intergroup comparisons of patient characteristics were made using the Student *t* test. Repeated data were tested for sphericity using the Mauchly test. If the Mauchly test was significant, indicating violation of the assumption of sphericity, we used the Greenhouse-Geisser ε adjustment. We used the univariate approach to analyze within-subjects effects. If there was a significant interaction between the between groups and within-subjects factors, we performed simple effects analysis of between-groups factors for all time levels. Furthermore, the between groups factors analyses were performed using death × time interaction.

Statistical significance was set at $p < 0.05$. Statistical analyses were performed with SPSS (Chicago version 20).

Results

Patients characteristics and outcome

From January to June 2013, we included in this study 20 patients with ARF and DNI decision. The characteristics of the 20 patients admitted are indicated in Table 1. Five out of 20 patients had home respiratory support before admission and 7 patients had been previously admitted in ICU or IRCU for ARF. These patients were considered as end-stage respiratory failure. COPD exacerbation, CPE and hypoxemic respiratory failure were the leading causes of ARF for our cohort of DNI patients. NIV was set with RR 13.6 ± 1.5 breaths/min, PS 16.1 ± 1.6 cm H_2O; PEEP 5 cm H2O; TI 0.7 ± 0.25 cm H_20, TE 49 % ± 6 %. After NIV treatment 15/20 patients were discharged alive, among them 12/20 used MV at home. Hospital mortality was 25 % (5/20 patients).

Reasons for refusal of admission in ICU and psychological morbidity

Table 2 reported the results of the psychologist's interview. The results were divided in two sections. First section reported caregiver's answers and second section, patient's answers. Many family members believed that "the patient in his condition is too much elderly to submit him to invasive procedures; if these are not avoidable we would go back home and refuse hospitalization". Ten caregivers referred that they did not accept admission in ICU because of "we would be able to keep on administering meals during break intervals of NIV". All family members asked "if it is possible for one family member stay night and day with patient if we accept NIV" and "To be able to allow the family members to be able to make visit to the patient in a timeframe without excessive restriction". The patients with end-stage respiratory failure referred "loss of hope" about admission in ICU. Four cancer patients presented unwillingness to discuss end-of-life care and allowed the choice to their relatives. Other patients who died refused all invasive procedures. Five patients referred lack of communications

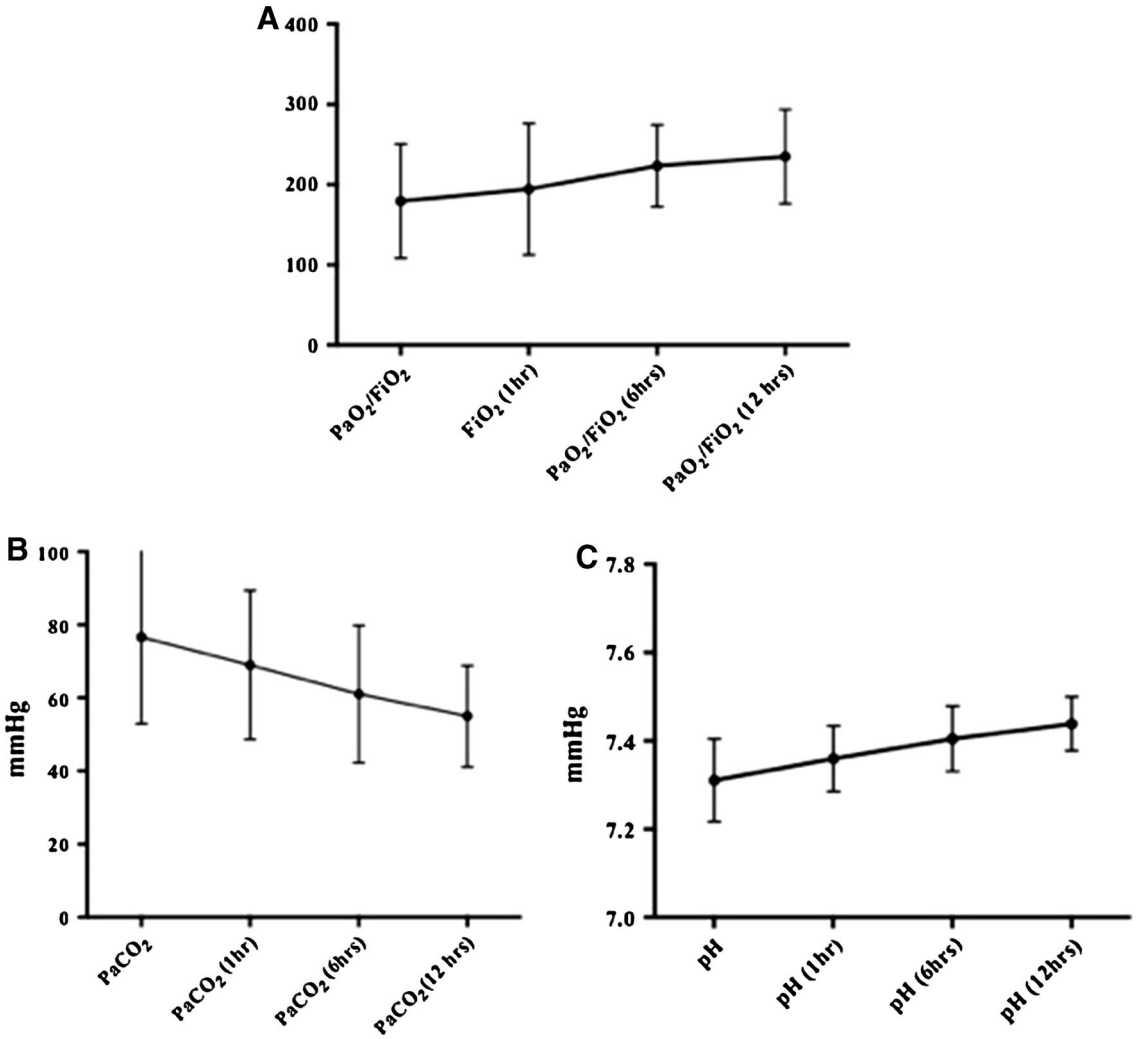

Fig. 1 **Panel A** PaO_2/FiO_2 levels at beginning and after 1, 6 12 h. **Panel B** $PaCO_2$ levels at beginning and after 1, 6 12 h. **Panel C** pH levels at beginning and after 1, 6 12 h

as "not sure which doctor will be taking care of me and not sure about cardiopulmonary procedures".

Respiratory exchanges

Figure 1 shows the value of PaO_2/FiO_2, $PaCO_2$ and PH measured at the admission and after 1, 6 and 12 h of NIV.

PaO_2/FiO_2 ratio was low at the admission but increased during the 12 h of NIV with statistical significance (PaO_2/FiO_2 at admission = 179.6 ± 71.1; after 1 h PaO_2/FiO_2 = 194.4 ± 81.8; after 6 h PaO_2/FiO_2 = 223.4 ± 50.9; after 12 h PaO_2/FiO_2 = 234.9 ± 58.6. W = 0.548; p = 0,023; ε = 0,746; PaO2/FiO2 at admission vs 12 h PaO_2/FiO_2 $p = 0.008$). $PaCO_2$ decreased during NIV with statistical significance ($PaCO_2$ at admission = 76.6 ± 23.7 mmHg; 1 h $PaCO_2$ = 69 ± 20.3 mmHg; 6 h $PaCO_2$ = 61 ± 18.7 mmHg; 12 h $PaCO_2$ = 55 ± 13.8 mmHg; $W = 0.474$; $p = 0.006$; $\varepsilon = 0.682$. $PaCO_2$ at admission vs 1 h $PaCO_2$ $p = 0.003$; 1 h $PaCO_2$ vs 6 h $PaCO_2$ $p = 0.001$; 6 h $PaCO_2$ vs 12 h $PaCO_2$; $PaCO_2$ at admission vs 12 h $PaCO_2$ $p = 0.000$). During NIV, also PH increased with statistical significance (pH at admission = 7.31 ± 0.1; 1 h pH = 7.35 ± 0.07; 6 h pH = 7.40 ± 0.07; 12 h pH = 7.43 ± 0.06; $W = 0.544$; $p = 0.021$; $\varepsilon = 0.704$. pH at admission vs 1 h pH $p = 0.021$; 1 h pH vs 6 h pH $p = 0.005$; 6 h pH vs 12 h pH $p = 0.027$; pH at admission vs 12 h pH $PaCO_2$ $p = 0.000$).

Survival/hospital mortality comparisons

Table 3 shows demographic characteristics, NIV settings and outcome of dead and alive patients.

Five of 20 patients died during the stay in geriatric ward while 15 patients were discharged alive. There is no

Table 3 Demographic characteristics, NIV settings and outcome of dead and alive patients

	Dead	Alive	*p* value
Patient (*n*)	5/20	15/20	
Age	85 ± 2.9	80 ± 10.3	0.09
APACHE III	93.2 ± 10.2	79.9 ± 14.8	0.01
ADL	3 ± 1.6	3.64 ± 1.9	0.37
IADL	2 ± 1	3.2 ± 3	0.17
Respiratory rate (breaths/min)	12.6 ± 1.4	14 ± 1.5	0.02
Pressure support (cm H_2O)	15.4 ± 1.5	16.4 ± 1.6	0.11
PEEP	5	5	1
TI (s)	0.7 ± 2	0.7 ± 2	1
TE (%)	49 ± 8	50 ± 6	0.74
Complication (*n*)	4/5	1/15	0.00
Number of comorbidities (Charlson index)	7.8 ± 1.09	5.0 ± 2.28	0.01
Type of comorbidities			
Cerebrovascular diseases	0	4	0.36
Active end-stage cancer with ARF	4	0	0.00
End-stage respiratory failure (with home respiratory support)	0	12	0.00
Sepsis with hypoxemic ARF and renal failure in liver cirrhosis	1	0	0.00
Post extubation condition	0	1	0.00
Heart failure	0	3	0.02
Full dependency for ADL	1	4	0.38
Discharge at home (*n*)	0/5	15/15	0.00
Discharged with MV at home (*n*)	0/5	12/15	0.00

Data were reported as mean ± standard deviation. The term cerebrovascular disease is comprehensive of vascular dementia. End-stage failure is comprehensive of patients with cor pulmonale, home respiratory support and previous ICU admission for ARF within the past years or FEV1 <30 % of predicted value

n number of patients

statistical difference in age, ADL and IADL values between dead and alive patients. NIV setting between dead and alive patients did not differ although alive patients had RR higher than that of dead patients (14 ± 1.5 and 12.6 ± 1.4 breaths/min, respectively; $p = 0.02$). APACHE III was significantly higher in dead group compared with alive group (93.2 ± 10.2 and 79.9 ± 14.8, respectively; $p = 0.01$).

Table 4 shows respiratory parameters of enrolled patients during NIV.

PaO_2/FiO_2 ratio in dead group remained stable around 200 while it increased in alive group after 12 h of NIV treatment without statistical significance ($p = 0.972$). $PaCO_2$ differed between the groups with statistical

Table 4 Comparison of respiratory parameters between dead and alive patents

	Dead	Alive	*p* value
PaO_2/FiO_2	221 ± 102.5	165.7 ± 55.1	0.972
PaO_2/FiO_2 (1 h)	195 ± 93.5	194 ± 81.1	
PaO_2/FiO_2 (6 h)	209.4 ± 78.4	228.2 ± 40.8	
PaO_2/FiO_2 (12 h)	204.6 ± 74.5	245 ± 51.4	
$PaCO_2$	58.2 ± 24.7	82.8 ± 20.6	0.042
$PaCO_2$ (1 h)	56 ± 24.1	73.3 ± 17.7	
$PaCO_2$ (6 h)	51.8 ± 24.6	64.1 ± 16.2	
$PaCO_2$ (12 h)	48.4 ± 23.2	57.2 ± 9.3	
pH	7.34 ± 0.1	7.29 ± 0.1	0.754
pH (1 hr)	7.37 ± 0.1	7.35 ± 0.05	
pH (6 h)	7.38 ± 0.1	7.41 ± 0.1	
pH (12 h)	7.39 ± 0.05	7.41 ± 0.01	

Data were reported as mean ± standard deviation

h hours

significance ($p = 0.042$). Arterial pH did not differ between dead and alive patients during the repeated measurement ($p = 0.754$).

Alive patients stayed more time in geriatric ward without statistical significance when compared with dead patients (9 ± 3.7 and 7.2 ± 4.3 days, respectively; p = 0.27).

Complications

Complications related to general patient conditions were significantly higher in the dead group compared to survivors; 4/5 dead patients while 1/15 alive patients experienced complications ($p = 0.000$). The most frequent complication was septic shock and/or severe metabolic acidosis. Only one patient was in post-extubated condition and was discharged home without MV. Mortality was higher in DNI patients with cancer and hypoxemic ARF and in patients with sepsis ($p = 0.01$). Four patients had nasal decubitus ulcers of grade 2 (hardening with loss of tissue that superficially involves the epidermis and the derma) [30] as NIV-related complications. Three patients had dryness of the faucis. No patients experienced aspiration, pneumonia, hypotension and pneumothorax.

Discussion

This study showed that in a cohort of very old patients (age >80 years) with ARF and DNI decision, 12 h of NIV, performed in a setting of half-open geriatric ward with close nursing and family supporting, ameliorated respiratory function, which allowed the discharge of 75 % of patients. In-hospital mortality was related to the

admission's diagnosis and was high in very old DNI patients with hypoxemic respiratory failure, or end-stage cancer [13]. Previous clinical trials on NIV for very old patients with ARF were conducted all in ICU, RICUs or sub-intensive care unit (SICU) by intensive care physicians and included patients with the median age of 75 [5–13].

In a recent study, Nava et al. [31] showed that patients with hypercapnic respiratory failure had better outcome when treated with NIV in ICU. Chandra et al. [32] in their review, reported a dramatic shift toward NIV use for treating acute respiratory exacerbations. The reasons of this trend were: health care providers become more confident with using NIV and expanded its application beyond those defined in clinical trials; a number of clinical trials have consistently reported that NIV is efficacious in reducing the need for invasive mechanical ventilation (IMV) and in-hospital mortality. Furthermore, because of the chronic shortage of ICU beds, NIV could be better implemented outside ICU rather than IMV, with reduction of ICU admissions. Some hospitals have therefore created special nursing units, commonly located next ICU, to facilitate NIV use [33]. British Thoracic Society guidelines established that patients with more severe respiratory acidosis (pH <7.30) should be managed with NIV in a higher dependency area such an RICUs or ICU as should those in whom improvement in clinical state and ABG tensions is not seen after 1–2 h of NIV on respiratory ward [34]. Since these guidelines on thorax in year 2002, NIV use increased exponentially in emergency room, in general ward, respiratory ward and in ICU and RICUs. The criteria of selection for the adequate setting are usually based on blood gas analyses and on patient's condition. Plant et al. [35] in their study showed that NIV was an option outside the ICU, but the outcome for patients with pH <7.30 was not so good as that seen for comparable patients in the study performed in a higher-dependence setting. This study was not designed to identify the best setting to deliver NIV through but showed that in selected patients, with exacerbations of hypercapnic COPD, pH >7.30 without need of mechanical ventilation, NIV may be started and maintained in the ward in which staff training and experience are adequate.

Nava et al. also showed in their study that most of these patients could be successfully treated with NIV and, therefore, they could also be treated in a medical ward, if the pH level is not dangerously low (i.e. >7.28) [13, 31]. Furthermore, patients with pH <7.25, neurological signs or hemodynamic compromise were usually admitted in ICU [36, 37].

In our study, patients with pH of 7.30 were admitted in half open-geriatric ward equipped by physicians adequately trained for NIV and, interestingly, pH improved after 6–12 h.

DNI decision means that "if I stop breathing, I will not be placed on an artificial breathing machine" or to possible tracheostomy procedures if appropriated. NIV was frequently applied for very old patients with DNI. Previous studies reported high mortality for DNI patients treated with NIV in ICU [38, 39]. Our study showed that when NIV is applied in a geriatric ward by experienced physicians, and if patients were closely assisted by family member and nurses, the mortality was about 25 %.

Dead patients had severe hypoxemic respiratory failure due to ARDS, sepsis and/or active cancer. In these patients $PaCO_2$ was lower than patients with global (hypoxemic and hypercapnic) respiratory failure and their worse outcome is related to severe hypoxemic value rather than lower $PaCO_2$ value. In hypoxemic ARF, NPPV can be successful in selected populations. When patients have a higher severity score, an older age, ARDS or pneumonia, or fail to improve after 1 h of treatment, the risk of failure is higher [40]. When NIV is used in acute hypoxemic respiratory failure it is mandatory to set definite end points and criteria for invasive ventilation [41]. Certain factors are predictive of the need for invasive mechanical ventilation and poor outcome as the presence of hepatic failure, Gram-negative bacilli isolated in blood culture, poor performance status, cancer status, older age and the number of organ failures at admission to ICU [42]. These patients had more severe APACHE III score and more severe Charlson comorbidities index. The appropriate use of such easily available clinical characteristics will help in deciding about the use of NIV. The DNI decision related to age and to very serious general conditions (active advanced cancer and sepsis in advanced chronic comorbidities) required NIV only as comfort treatment at end of life. They had severe complications related their general problems as metabolic acidosis with increased lactates. One of the mechanisms of compensation is hyperventilation with decreased $PaCO_2$. The complications in this context were obviously great.

NIV-related complications could compromise adaption to ventilator. We treated nasal decubitus ulcers with some reinforcements applied on the masks that lift the apex of the device on the skin. In some cases very adherent fixing used for reducing to the least the losses was the cause of ulcers. Three patients had dryness of the faucis corrected improving the system of humidification.

The answers to psychologist's interview reflect a cultural contest in which family members often request that their very elderly patients can die in their own house. They referred the desire to assist their patients as they did to house. Informed consent is the mainstay of self-determination. About lack of comunication, Murphy et al. [43] have shown that elderly patients' preference for cardiopulmonary resuscitation decreases from 41 to 22 % after extensive information about procedure and prognosis. During a severe acute illness, elderly patients are often unable to express their wishes. In these situations,

caregivers have to extrapolate these preferences, basing their decisions on information provided by relatives. In our experience, the active involvement of patient relatives in the process of assistance reduces the level of anxiety and of pain. Admission in ICU, mechanical ventilation, possible tracheotomy and enteral/parenteral nutrition, exclude the involvement of the family members. The ICU is therefore sight how a barrier especially for the patients at the end of the life. In our half-open geriatric ward is possible that a family caregiver was present in the ward throughout the day with the particular task of administering the meals; other family members could visit patients in established visit time (4 h per day). Four patients had active cancer with acute respiratory failure. In the management of pain for these patients the presence of family members was an important component of reduced anxiety pain related additionally to the analgesic medicines decided with specialist of pain management.

The patients with previous home MV were patients with stable hypercapnic COPD. Some considerations about this kind of patients should be made. The GOLD guidelines(update 2013s) [44] for the management of COPD stage IV (very severe COPD) with FEV1/FVC <70 %, FEV 1 < 30 % predicted or FEV 1 < 50 % predicted plus chronic respiratory failure foresee ventilatory support as non pharmacological, recommended treatment. NIV is increasingly used in patients with very severe stable COPD. The combination of NIV with long term oxygen therapy may be of some use in a selected subset of patients particularly in those with pronounced daytime hypercapnia. It may improve survival but not improve quality of life [45]. However in patients with both COPD and obstructive sleep apnea there are clear benefits from continuous airway pressure in both survival and risk hospital admission [46].During COPD exacerbations these patient had elevated risk of ETI and possible tracheotomy. At the base of exacerbations we considered in the management of these patients: effective hours of ventilation at home; daytime hypercapnia; evaluation of "if they are true responders"; control ventilator setting; maximizing therapy with bronchodilators and corticosteroids; treating possible infection and checking comorbidities and rehabilitation.

The intolerance and the scarce compliance to the interface are frequent problems during NIV. In the collaborating patient a correct choice of the way of ventilation and an accurate choice of the mask are required. The prevention of the NIV collateral effects is needed. The initial discomfort and claustrophobia could be resolved with light fixing on the mask, explaining each medical action and asking to patient his sensations. In our experience we performed NIV, after a continuous period of 12 h, to cycles with a break of suspension during the meals of 2 h if appropriated. Also for the tolerance the family support has been of help into convince the patients to continue the NIV when they were tired.

Our study showed that trained and experienced are probably more important than the environment (provide the staff is numerically adequate) and there is for sure a "learning" effect when using NIV. [47, 48] Experience means not only increase the skill, but also avoiding treating patients not likely to respond to NIV. Through continuing training and protocols we could determine the rate of success of the NIV.

In our study, using NIV in half-open ward with the presence of family member may reduce patient's anxiety and improve comfort even at the end of life. Furthermore, the involvement of family member to provide support during the evaluation of patient healthcare issue has been reported as a positive experience [49]. The use of NPPV in general wards could be a safe and effective option, as a last choice treatment [50] and for patients choosing comfort measures only, many physicians include NIV as an valid option of treatment [51]. In-hospital geriatric ward NPPV could be successful in reversing acute respiratory failure and preventing hospital mortality in DNI patients with COPD and cardiogenic pulmonary edema, but not in hypoxemic respiratory failure, or end-stage cancer.

Conclusions

Very old DNI patients with ARF could be treated with NIV in half-open geriatric ward with trained physicians and nurses. The presence of family members may improve patients' comfort and reduce anxiety level even at the end of life. In-hospital geriatric ward mortality was related to the admission diagnosis. Further studies are needed to address the effective role of NIV in very old patients with DNI decisions.

Limitations

This study had some limitations that needed to be addressed. This is an observational not randomized study performed in a single center. Patients enrollment was difficult according the age >80 years and DNI decisions. Data should not be generalized because of the limited cohort of patients consecutively enrolled in a period of 6 months. Furthermore, data refers to a half-open geriatric ward with physicians and nurses trained in management of NIV.

Acknowledgments We wish to thank Mrs. Ivana Nappa, coordinator of the staff of nurses, for the excellent job done.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix 1

At the admission in our ward, a nurse was assigned to the patients with NIV to train the family members. As follow we reported the checklist of nurse instruction for family members:

1. The difference between interfaces (mask) as the whole nose (full nasal mask; only the nostril-nasal plugs or nasal pillow-); nose and mouth (total face mask); nose, mouth and eyes (total full face mask); helmet
2. How to recognize air leaks and how to modify the system of fixing of masks if appropriated
3. How to recognize an activated alarm
4. How to turn on and extinguish the ventilator during suspension for meals
5. What to do if vomit, discomfort, claustrophobia, nasal or eyes congestion or gastric distension appear
6. Family members cannot modify the parameters of ventilator (there is specific pulsating block)
7. At discharge if patient need home ventilator a specialized technician of home ventilator imposes the parameters and he explains the instructions to the family members

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