Journal of Critical Care 30 (2015) 1390–1394

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Prone positioning improves oxygenation in spontaneously breathing nonintubated patients with hypoxemic acute respiratory failure: A retrospective study☆,☆☆,★

Vittorio Scaravilli [a,*], Giacomo Grasselli [b], Luigi Castagna [a], Alberto Zanella [a], Stefano Isgrò [b], Alberto Lucchini [b], Nicolò Patroniti [a,b], Giacomo Bellani [a,b], Antonio Pesenti [a,b]

[a] Dipartimento di Scienze della Salute, Università degli Studi di Milano Bicocca, Via Cadore 48, 20900, Monza, MB, Italy
[b] Dipartimento di Emergenza e Urgenza, Ospedale San Gerardo, Via Pergolesi 33, 20900, Monza, MB, Italy

ARTICLE INFO

Keywords:
Prone position
Pulmonary gas exchange
Hypoxia
Pulmonary ventilation
Noninvasive ventilation
Retrospective studies

ABSTRACT

Purpose: Prone positioning (PP) improves oxygenation and outcome of patients with acute respiratory distress syndrome undergoing invasive ventilation. We evaluated feasibility and efficacy of PP in awake, non-intubated, spontaneously breathing patients with hypoxemic acute respiratory failure (ARF).
Material and Methods: We retrospectively studied non-intubated subjects with hypoxemic ARF treated with PP from January 2009 to December 2014. Data were extracted from medical records. Arterial blood gas analyses, respiratory rate, and hemodynamics were retrieved 1 to 2 hours before pronation (step PRE), during PP (step PRONE), and 6 to 8 hours after resupination (step POST).
Results: Fifteen non-intubated ARF patients underwent 43 PP procedures. Nine subjects were immunocompromised. Twelve subjects were discharged from hospital, while 3 died. Only 2 maneuvers were interrupted, owing to patient intolerance. No complications were documented. PP did not alter respiratory rate or hemodynamics. In the subset of procedures during which the same positive end expiratory pressure and F_{IO_2} were utilized throughout the pronation cycle (n = 18), PP improved oxygenation (P_{AO_2}/F_{IO_2} 124 ± 50 mmHg, 187 ± 72 mmHg, and 140 ± 61 mmHg, during PRE, PRONE, and POST steps, respectively, $P < .001$), while pH and P_{ACO_2} were unchanged.
Conclusions: PP was feasible and improved oxygenation in non-intubated, spontaneously breathing patients with ARF.

1. Introduction

Acute respiratory failure (ARF) is a common cause of intensive care unit (ICU) admission [1]. Patients with severe ARF are usually managed with intubation and invasive mechanical ventilation (MV), but their clinical course is frequently complicated by ventilator associated pneumonia (VAP) [2]. The risk of VAP is particularly high in patients with malignancies, immunocompromise, and chronic obstructive pulmonary disease (COPD) [3–6]. Especially in these patient groups, VAP may adversely affect the clinical outcome [7,8]: thus, it is commonly suggested to avoid intubation and, whenever possible, to employ non-invasive ventilation (NIV) [9,10].

Prone positioning (PP) during invasive MV has been demonstrated to improve oxygenation and reduce mortality of the most severe acute respiratory distress syndrome (ARDS) patients [11–13]. In theory, these benefits should apply also to non-intubated patients, in whom PP may improve oxygenation while delaying or even avoiding the need for intubation. This may be particularly useful in patients at high risk of VAP [14].

Reports of the application of PP in spontaneously breathing, non-intubated adult patients are limited to few case reports [15–17].

In this retrospective observational study, we reviewed the 5-year experience of our ICU in the application of PP in awake, non-intubated, spontaneously breathing patients with hypoxemic ARF, describing the effect of PP on oxygenation, breathing patterns, and hemodynamics.

2. Material and methods

The study protocol was approved by the local Ethics Committee. Written informed consent was not deemed necessary due to the

☆ Authors contributions: All authors provided substantial contributions to the conception and design, acquisition of data, analysis, and interpretation of findings. Dr Scaravilli and Dr Castagna retrospectively collected and performed analyses of data. Dr Scaravilli, Dr Grasselli, Dr Castagna, Dr Bellani, and Dr Zanella drafted the manuscript and all authors contributed substantially to revisions. All authors gave approval for the final version submitted for publication.

☆☆ Financial Support: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

★ Disclosures and Conflict of interest: The authors report no conflict of interest.

* Corresponding author at: Dipartimento di Scienze della Salute, Università degli Studi di Milano Bicocca, Via Cadore 48, Monza, MB, 20900, Italy. Tel.: +39 0392332127; fax: +39 0392332297.
E-mail address: vittorio.scaravilli@gmail.com (V. Scaravilli).

http://dx.doi.org/10.1016/j.jcrc.2015.07.008
0883-9441/

retrospective design of the study. The medical records of patients admitted to the general ICU of San Gerardo Hospital (Monza, Italy) from January 2009 to December 2014 were retrospectively screened for the following inclusion criteria: (1) arterial partial pressure of oxygen to inspired fraction of oxygen ratio (Pa_{O_2}/F_{IO_2}) lower than 300 mm Hg; (2) at least one application of PP in absence of endotracheal intubation.

Demographic data (ie, gender, age), comorbidities, diagnosis at ICU admission, severity scores (ie, Acute Physiology and Chronic Health Evaluation II score [APACHE II] and Simplified Acute Physiology Score II [II] of the first 24 hours of ICU stay), ICU length of stay (LOS), hospital LOS, outcome at hospital discharge as well as incidence of endotracheal intubation after the application of PP were recorded. Subjects undergoing immunosuppressive therapies (including long-term or high-dose steroids) or suffering from hematological or advances solid malignancies were defined as "immunocompromised".

To evaluate feasibility, the duration of each PP procedure was recorded, as well as occurrence of known complications of PP (ie displacement of indwelling catheters, facial edema, pressure sores, pressure neuropathies, compression of nerves and retinal vessels, vomiting, and intolerance to the maneuver) [18] as recorded in the medical and nursing charts.

To evaluate the clinical effects of PP, during each pronation procedure 3 different time points were identified: 1 to 2 hours before pronation (step PRE), the last hour of PP (step PRONE) and 6 to 8 hours after resupination (step POST). At each time point the following variables were recorded: type of respiratory device (ie, oxygen supply mask, high-flow nasal cannulas, helmet continuous positive airway pressure [CPAP], NIV mask), respiratory setting (ie, fraction of inspired oxygen [F_{IO_2}], positive end expiratory pressure [PEEP]), arterial blood gas analyses, Pa_{O_2}/F_{IO_2}ratio, heart rate, arterial blood pressure, central venous pressure, respiratory rate, dosage of vasopressors and sedative drugs as well as Richmond Agitation Sedation Scale (RASS). Finally, the daily Nurse Activity Score (NAS) [19] was recorded. PEEP delivered by high flow nasal cannulas was considered equal to 4 cmH_2O [20].

2.1. Statistical analyses

Data are presented as mean ± SD or median (interquartile range), when appropriate. For normally distributed variables, one-way analysis of variance (ANOVA) for repeated measurement with a post hoc Tukey's correction was used to compare data of the different steps. For non-normally distributed variables, the Kruskal-Wallis test was performed. $P < .05$ was considered statistically significant. Statistical analysis was performed using the JMP 11 statistical software (SAS, Cary, NC).

3. Results

From January 2009 to December 2014, 15 non-intubated patients (5 females and 10 males) with Pa_{O_2}/F_{IO_2} less than 300 mmHg were treated with PP. Patients' characteristics are summarized in Table 1. Fourteen patients were adults (median age was 66 [52.5-78.5] years old) while one patient was 16 years old. Nine patients were immunocompromised. Five had previous COPD diagnosis and 4 suffered from malignancies. The median value of SAPS II and APACHE II score were 42 (30.25-49) and 17.5 (15-21.25), respectively. Median ICU LOS was 9 (7-9) days, while the median hospital LOS was 26 (18-31) days. Only 2 subjects (13%) required intubation during the ICU stay. Three subjects died in the ICU, while the other 12 were discharged from the hospital (survival rate 80%).

During the study period, a total of 43 PP procedures were performed, with a median of 2 (1-3) procedures per subject. PP was applied for the first time after a median interval of 2 days (1-3) from admission. The median duration of PP cycles was 3 (2-4) hours and the longest procedure lasted 8 hours.

Patients were managed with different respiratory devices, PEEP, and F_{IO_2} levels, as shown in Table 2. In 18 PP procedures the same respiratory support (ie, type of device, PEEP, and F_{IO_2}) was utilized before, during, and after the pronation cycle. In 10 of those 18 PP procedures non-invasive positive pressure ventilation was applied with the same setting (ie, type of device, PEEP, and F_{IO_2}) before, during, and after the pronation cycle.

Effect of PP on Pa_{O_2}/F_{IO_2} is shown in Fig. 1. In the subset of PP procedures without changes in respiratory support ($n = 18$): mean Pa_{O_2}/F_{IO_2} was significantly higher during PRONE step (187 ± 72 mmHg), as compared to PRE (124 ± 50 mmHg) and POST steps (140 ± 61 mmHg) ($P < .001$). Similarly, in the subset of procedures performed during non-invasive positive pressure ventilation ($n = 10$), mean Pa_{O_2}/F_{IO_2} was significantly higher during PRONE step (214 ± 71 mmHg), as compared to PRE (157 ± 44 mmHg) and POST steps (160 ± 69 mmHg) ($P < .001$). Among the overall population, mean Pa_{O_2}/F_{IO_2} was significantly higher during PRONE step (186 ± 72 mmHg), as compared to PRE (127 ± 49 mmHg) and POST steps (141 ± 64 mmHg) ($P < .05$).

Effect of PP on arterial blood gas analyses is represented in Table 3. In the subset of PP procedures without changes in respiratory support ($n = 18$), Pa_{O_2} was significantly higher during PRONE step than during PRE and POST steps, while oxygen saturation of arterial hemoglobin (HbO_2) was significantly higher during PRONE step as compared to PRE step but not to POST step. In the subset of patients undergoing PP while on non-invasive positive pressure ventilation ($n = 10$), similar statically significant differences in Pa_{O_2} and HbO_2 were observed.

Table 1
Patients' characteristics

Patient	Age (years)	Gender	ICU diagnosis	Immunocompromized	COPD	Malignancy	APACHE II	SAPS II	Endotracheal intubation	ICU LOS	Hospital LOS	Hospital outcome
1	75	M	Pneumonia	X	X	X	21	42		7	35	Discharged
2	71	F	Pneumonia	X			22	39		8	31	Discharged
3	14	M	Pneumonia				N.A	N.A.		7	18	Discharged
4	36	M	Pneumonia	X			15	21		5	15	Discharged
5	58	M	Pneumonia		X		23	49		7	26	Discharged
6	61	M	Fascitis				18	28		4	21	Discharged
7	63	M	Pneumonia	X			15	46		9	27	Discharged
8	80	F	Pneumonia		X	X	17	59		8	30	Discharged
9	65	M	Pneumonia		X		15	24	X	50	80	Discharged
10	67	M	Pneumonia		X		11	40		8	13	Discharged
11	80	F	Pneumonia	X		X	19	55		5	7	Dead
12	78	M	Pneumonia				16	49		9	26	Discharged
13	80	M	Pneumonia	X			21	42		7	23	Discharged
14	19	F	Pneumonia	X		X	16	31		26	34	Dead
15	28	F	Sepsis of unknown origin	X			27	43	X	15	25	Dead