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Prone Positioning and Clinical Outcomes of Mechanically Ventilated Patients with Severe Acute Respiratory Distress Syndrome

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***Abstract*—**Acute respiratory distress syndrome (ARDS) is characterized by permeability pulmonary edema and refractory hypoxemia. Lung-protective ventilation is still the key of better outcome in ARDS. Prone position reduces the trans-pulmonary pressure gradient, recruiting collapsed regions of the lung without increasing airway pressure or hyperinflation. Prone ventilation showed improved oxygenation and improved outcomes in severe hypoxemic patients with ARDS. This study evaluates the effect of prone positioning on mechanically ventilated patients with ARDS. A quasi-experimental design was carried out at Critical Care Units, on 60 patients. Two tools were utilized to collect data; Socio demographic, medical and clinical outcomes data sheet. Results of the present study indicated that prone position improves oxygenation in patients with severe respiratory distress syndrome. The study recommended that use prone position in patients with severe ARDS, as early as possible and for long sessions. Also, replication of this study on larger probability sample at the different geographical location is highly recommended.

***Keywords*—**Acute respiratory distress syndrome, Critical care, Mechanical ventilation and Prone position.

I. Introduction

Acute respiratory distress syndrome (ARDS) is a life threatening respiratory condition characterized by hypoxemia, and stiff lungs, without mechanical ventilation most patients would die. Since its first description in 1967, there have been a large number of studies addressing various clinical aspects of the syndrome. The Berlin definition developed at 2012 considered the most applicable diagnostic criteria which consist of; timing within one week of a known clinical insult or new or worsening respiratory symptoms, chest x-ray had bilateral opacities, the origin of edema is due to respiratory failure not fully explained by cardiac failure or fluid overload. ARDS was divided into three categories of severity based on the P/F ratio - mild (from 201 to 300 mmHg), moderate (from 101 to 200 mmHg), and severe (≤100 mmHg). A positive end-expiratory pressure value of at least 5 cm H_2O became required for the diagnosis of ARDS. The Berlin definition brought improvement and simplification over the previous definitions and decrease mortality rates [1].

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Prone positioning has been known for decades to improve oxygenation in acute lung injury (ALI) and in most patients with ARDS. The mechanisms of this improvement include a more uniform pleural-pressure gradient, a smaller volume of lung compressed by the heart and better-matched ventilation and perfusion. Prone positioning has an established niche as an intervention to improve gas exchange in patients with severe hypoxemia refractory to standard ventilatory manipulations. Because the lung may be more uniformly recruited and the stress of mechanical ventilation better distributed, prone positioning has also been proposed as a form of lung-protective ventilation. However, several randomized trials have failed to show improvements in clinical outcomes of ARDS patients, other than consistently better oxygenation. Because each of these trials had design problems or early termination, prone positioning remains a rescue therapy for patients with acute lung injury or ARDS [2].

Studies found improved oxygenation in about 70% of patients with ALI/ARDS when flipped from supine to prone. Prone positioning is an ideal approach to lung protection during mechanical ventilation for ALI/ARDS. It requires no special equipment. It is applicable to almost all patients, excluding only those with abdominal wounds, tenuous vascular or airway access, or similar conditions. In patients with cardiomegaly, it improves ventilation to dorsal lung regions without compensatory worsening of ventral ventilation, reducing the local injurious stress and strain. Adverse effects have been rare and are largely avoidable. Prone position also improves oxygenation in most patients, allowing reduction in fraction of inspired oxygen or PEEP. Although definitive survival data from clinical trials are lacking [3].

Prone positioning requires more diligent care from the critical care nurse practitioner in ICU. The following specific set of skills are needed to care for the patient in the prone position: recognizing when prone positioning may be beneficial, being able to communicate with the patient's family about the therapy, maintenance of invasive lines and tubes to prevent dislodgement, and regular skin assessments and interventions to prevent skin breakdown in vulnerable areas during prone positioning. The patient positioning falls under the nursing domain in patient care and states that critical care nurses should be proactive with turning patients with ARDS. Nurse should determine if the risks of prone positioning are outweighed by the patient's need for improved oxygenation or if there are any contraindications, also monitor for potential complications. A team approach is best to keep mechanically ventilated patients safe. Nurse should offer emotional and educational support to the patient's family [4].

II. Material and Methods

A. Aim of the Study

The aim of this study is to evaluate the effect of prone positioning on clinical outcomes among mechanically ventilated patients with severe acute respiratory distress syndrome.

B. Operational Definition

1. Prone Position

A position with the patient lying down on the chest and abdomen with arms bent comfortably at the elbow or straight and head turned to lateral side.

2. Clinical Outcomes

Measuring & monitoring of hemodynamic parameters as:

- Vital signs (Temperature, Respiration, Heart rate and Blood pressure).
- SaO_2 from pulse oximetry.
- Arterial blood gases (ABGs) parameters.
- Mechanical ventilator parameters.
- Improvement of oxygenation, ventilation and perfusion as PaO_2> 60mmHg or SaO_2>88%, FiO_2 < 60%, and PaO_2/FiO_2 > 150 mmHg.

3. Severe Acute Respiratory Distress Syndrome (ARDS)

If the P/F ratio (≤100 mmHg) and the positive end-expiratory pressure (PEEP) value are at least 5 cm H_2O, it is considered severe ARDS according to Berlin definition 2012 [5].

C. Research Hypotheses

To fulfill the aim of this study the following research hypotheses was formulated:

1. Mechanically ventilated patient with severe ARDS who assume prone position will experience improvement in Vital Signs.
2. Mechanically ventilated patient with severe ARDS who assume prone position will experience improvement in Arterial Blood Gases results.

D. Research Design

This study was conducted using a quasi-experimental design.

E. Setting

The study was carried out at Critical Care Units, which had patients diagnosed with ARDS.

F. Sample

Convenience sample of 60 male and female adult patients had severe ARDS were admitted to the selected critical care units within 6 months.

Criteria of Inclusion:

1. On 1st 48 hours after mechanical ventilation (Low tidal volume ventilation strategy)
2. Severe ARDS as diagnosed by the following criteria:
   - Time: Acute onset within one week of respiratory event
   - Chest X-ray: Bilateral opacities
   - Origin of edema: Respiratory failure, non-cardiac
   - Oxygenation: PaO_2/FiO_2< 100 mmHg with PEEP > 5 mmHg
3. PaO_2< 60 mmHg or SaO_2< 88% or FiO_2> 60%

Criteria of Exclusion:

1. Patients contraindicated to prone position as:
   - Unresponsive cerebral hypertension
   - Unstable bone fractures or facial fracture or spinal instability
   - Left sided heart failure
   - Hemodynamic instability
   - Active intra-abdominal or chest pathology or surgery
   - Massive hemoptysis
2. On mechanical ventilation with high tidal volume
3. On mechanical ventilation more than 2 days
4. Patients with tracheostomy

G. Tools

To achieve the aim, data pertinent to this study were collected utilizing two tools. These tools were constructed by the researcher then revised by a panel of 5 critical care nursing and medical expertise and piloted on 10% of the study subjects. These tools are:

- Tool 1: Socio demographic and medical data sheet: covers age, gender, admission date, height, weight, diagnosis, past medical history, initial vital signs, base line information physiological parameters.
- Tool 2: Clinical outcomes data sheet:
  - Arterial blood gases values (ABGs) pre, during and post prone position.
  - Oxygen saturation by pulse oximetry pre, during and post prone position.
  - Vital signs (Temperature, pulse, blood pressure and respiratory rate). Pre, during and post prone position.
  - Ventilator parameters according to lung protective strategies conventional therapy (ARDSNET) Pre, during and post prone position.

H. Pilot Study

Pilot study was conducted on 10% of the sample according to inclusion criteria to test the feasibility, objectivity, validity and applicability of the study tools. The needed modification was done, and the pilot was included in the study sample.

I. Legal and Ethical Considerations

Once the official permission from ethical committee is granted to proceed with the proposed study, Participation in this study was voluntary; each subject had the right to withdraw from the study without any rational. Informed consent was obtained from the patients if conscious or their relatives if sedated or unconscious. Confidentiality and anonymity of the subjects were assured through coding of all data. All subjects were exposed to the routine hospital care. Patients were assured that these data will not be reused in another research without their permission.

J. Procedure

This study was conducted on two phases; preparatory and implementation phases.

1. The Preparatory Phase

Involves preparation of the study tools and testing its validity. Once permission was granted to proceed with the proposed study; the selected Critical Care Units were informed about the protocol of care, patient or relative who were agree to participate in the study was interviewed individually by researcher to explain the nature and purpose of the current study. A written consent was obtained.

2. The Implementation Phase

The researcher was initiate data collection. First Socio demographic and medical data sheet (Tool 1) was filled out by the researcher for each patient during the first 48 hours of their admission, then clinical outcomes data sheet (Tool 2) was recorded for each patient before changing position. Then changing patient into prone position for 18 hours and physiological parameters were also recorded at 9 hours from obtaining the position and immediately before returning to supine position. This was done for each patient once every day continuously for 3 days with continuous monitoring and close observation by the researcher. Finally, the mean of the all observations after 3 days were calculated and compared with the on admission parameters. If patient deteriorated on prone position, he/she was returned rapidly to supine position and was excluded from the study sample.

III. Result

Table I shows that the majority of the studied sample were males and their age more than 50 years.

TABLE I
PERCENTAGE DISTRIBUTION OF THE STUDIED SAMPLE AS REGARDS TO THEIR GENDER & AGE CATEGORIES (N=60)

Variables	No.	%
Gender		
Male	51	85%
Female	9	15%
Age Categories		
30-40	5	8.3%
41-50	14	23.3%
> 50	41	**68.3%**
Mean ± SD	**53.98 ± 9.98**	

Table II shows that the before prone position 61.67% of the studied sample did not need inotropic drugs then during the prone positions the percentage decreased to 51.7% but after prone position it was increased again to 65%.

Table III shows that the means of ventilator parameters of the studied sample.

TABLE II
PERCENTAGE DISTRIBUTION OF THE STUDIED SAMPLE AS REGARDS TO ADMINISTRATION OF INOTROPIC DRUGS PRE, DURING, AND POST PRONE POSITION (N=60)

Variables		No.	%
Administration of Inotropes			
Pre- Prone	Yes	23	38.33 %
	No	37	**61.67 %**
During Prone	Yes	29	48.33 %
	No	31	**51.7 %**
Post- Prone	Yes	21	35 %
	No	39	**65 %**

TABLE III
THE MEAN OF THE STUDIED SAMPLE MECHANICAL VENTILATOR PARAMETERS (N=60)

Variables	Mean ± SD	Min.	Max.
Mode	CMV		
Vt	343.5 ± 36.68	300	450
FiO_2	86.17 ± 9.58	70	100
PEEP	15.9 ± 1.39	14	18
R.R.	23.35 ± 2.31	20	28

Table IV shows that the means of the studied sample vital signs pre, during and post prone position were within normal ranges and there was any significant difference between them.

TABLE IV
THE MEANS OF THE STUDIED SAMPLE VITAL SIGNS & THE CORRELATION BETWEEN (PRE - DURING - POST). (N=60)

Variables		Mean ± SD	Min.	Max.	F / P
T	Pre	37.7 ±.69	37	39	1.7 / .19
	During	37.7± .69	37	39	
	Post	37.5± .67	36.5	40	
P	Pre	96.8±13.4	70	120	2.7 / .07
	During	98 ± 13.33	70	120	
	Post	93 ± 10.3	70	120	
Bl.P Systole	Pre	115.4±14.3	98	150	.54 / .58
	During	112.8 ± 13.8	90	140	
	Post	113.8 ± 12.9	90	140	
Bl.P Diastole	Pre	67.5 ± 7.44	60	90	.58 / .56
	During	68.5 ± 9.17	60	90	
	Post	69.03 ± 7.7	60	80	

Table V shows that the majority of the studied sample pre prone position were had respiratory acidosis, hypoventilation & hypoxia (PH=7.31 ±.04, PaO_2=56.47 ± 5.03, $PaCO_2$=46.18 ± 8.13, O_2 Sat.= 87.4 ± 2.02). Then O_2Sat improved during and after prone position (89.98 ± 1.8, 90.7 ± 1.9) respectively. There was highly significant statistical difference in PaO_2, $PaCO_2$ and O_2 Saturation results (76.6 / .000, 12.7 / .000, 49.7 / .000) respectively.

TABLE V
THE MEANS OF THE STUDIED SAMPLE ARTERIAL BLOOD GASES (ABG) & THE CORRELATION BETWEEN (PRE - DURING - POST) (N=60)

Variables		Mean ± SD	Min.	Max.	F / P
PH	Pre	7.31 ±.04	7.26	7.39	1.8 / .17
	During	7.34 ± .04	7.28	7.41	
	Post	7.32 ± .13	6.33	7.41	
PaO_2	Pre	56.47 ± 5.03	50	71	**76.6 / .000**
	During	76.45 ± 11.11	52	95	
	Post	68.6 ± 9.5	51	88	
$PaCO_2$	Pre	46.18 ± 8.13	30	64	**12.7 / .000**
	During	42.23 ± 5.8	30	54	
	Post	40.23 ± 5.5	30	56	
HCo_3	Pre	20.40 ± 3.82	14	30	.24 / .79
	During	20 ± 2.89	15	28	
	Post	20.15 ± 2.9	14	26	
O_2 Saturation	Pre	87.4 ± 2.02	83	92	**49.7 / .000**
	During	89.98 ± 1.8	87	93	
	Post	90.7 ± 1.9	83	93	

IV. DISCUSSION

Positioning is one of the most frequently performed nursing activities in critical care, often providing a central critical focus for planning other nursing activities. It has been observed from the researcher's clinical experience that patient's position changes are always done as a routine, however, it did not include prone position which is literature supported to improve oxygenation among hypoxemic patients. Also a lot of recent randomized control trials (RCTs) support that prone ventilation may improve mortality in some patients with severe ARDS either oxygenation.

One observational study of 218 patients with severe ARDS reported a mortality of 19%, well below the expected mortality for this population. Additionally, a meta-analysis of patients with severe ARDS from seven randomized trials (555 patients) found that prone ventilation reduced mortality (53 versus 63%, RR 0.84, 95% CI 0.74-0.96). Another meta-analysis reported that the mortality benefit existed only in patients who were receiving prone ventilation plus low tidal volume ventilation. The benefits of prone ventilation in this subpopulation is further supported by a single large randomized trial of early (within 33 hours of intubation), high-dose (17 consecutive hours) prone ventilation for severe ARDS. This trial of 466 patients receiving low tidal volume mechanical ventilation for severe ARDS, reported that, compared to patients ventilated in the supine position, patients receiving prone ventilation (average time spent prone: 73%) had a reduction in 28-day mortality (16 versus 33%; hazard ratio [HR], 0.39; 95% CI, 0.25-0.63) and 90-day mortality (24 versus 41%; HR, 0.44; 95% CI, 0.29-0.67, respectively). The mortality benefit occurred without excess risk of complications [6].

Although, a lot of critical care unit around the world start to apply this therapeutic prone position for this target group of patient and with present of many evidence-base studies to support its effects, the mortality rate for ARDS patients still high.

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