Effect of Prone Positioning on Hemodynamic Parameters among Pregnant Women with COVID-19-related Hypoxemia

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Abstract

The current study aimed to evaluate the effect of prone positioning on hemodynamic parameters among pregnant women with COVID-19-related hypoxemia. **Materials and method:** A quasi-experimental pre-posttest design was utilized. The study was carried out at the ICU in Mansoura university hospital, one of the isolation hospitals assigned to receive covid-19 patients. A purposive sample consisting of 36 pregnant women with confirmed COVID-19 was selected according to the inclusion criteria. Data was collected through a Structured Interview Questionnaire, Hemodynamic and Oxygenation Parameters chart, and Visual Analog Scale for dyspnea and discomfort. **Results:** There was a significant difference between pre and post-test results in favor of post-intervention. Whereas, there was an improvement in most hemodynamic parameters mean scores after prone positioning evidenced by a significant increase in the average measurement of Peripheral oxygen saturation, PH, Arterial oxygen saturation, and PaO_2 and a significant decrease in the average measurement of Respiratory Rate, $PaCO_2$, PaO_2/FiO_2, and heart rate. Also, the fetal heart rate mean scores significantly decreased from 165.25 ± 18.10 beats/minute to 148.97 ± 14.47 beats/minute after prone positioning. Moreover, there was a significant improvement in dyspnea levels after applying for the prone position; the moderate and severe dyspnea decreased from 58.3% to 8.3% and the discomfort level had shown significantly decreased. There was a positive significant strong ($r=0.924$, $P<0.001$) correlation between dyspnea and discomfort level before practicing prone positioning. **Conclusion:** The current study findings highlighted that applying a prone positioning had a highly statistically significant effect on improving the hemodynamic parameters and decreasing dyspnea and discomfort levels among pregnant women with COVID-19-related hypoxemia as well as the fetal heart rate. **Recommendations**: Large-scale studies in different ICUs in many hospitals are needed to provide strong evidence about the effectiveness of the prone position in non-intubated and intubated pregnant patients infected with COVID-19.

Keywords: COVID-19, Hemodynamic Parameters, Prone positioning, Pregnant Women.

Introduction:

The increased mortality and morbidity rate caused by coronavirus 2019 (COVID-19) among pregnant women can be attributed to both pathophysiological conditions inherent in the pregnancy process and illness caused by infection **(Souto, Albuquerque, & Prata (2020).** Severe respiratory disease management during pregnancy throughout the current pandemic is complex. Applying prone positioning in hypoxemic pregnant women, especially with advanced gestational ages (≥ 34 weeks of gestation) needs meticulous care to be considered. When lung-protective ventilation in the supine position fails to meet oxygenation goals in patients with acute respiratory distress syndrome (ARDS), it is recommended to use other techniques to improve the oxygenation such as inverse ratio ventilation, permissive hypercapnia, prone position ventilation (PPV) **(Koulours, Papathanakos, Papathanasiou, and Nakos, 2016).**

Prone Positioning (PP) has been studied as part of the treatment of patients with ARDS since the 1970s. Sustained (PP) for at least twelve hours/day is applied to minimize mortality rate in patients with moderate-to-severe ARDS and is now the standard of care in their management., its utilization for the non-intubated hypoxemic patient has been growing up since the COVID-19 pandemic. Prone position has been found to improve oxygenation and decrease mortality, according to the recent global anecdotal findings, it has proven to be particularly beneficial for patients diagnosed with COVID-19 and has moderate to severe respiratory symptoms **(Testani, Twiehaus, Waters, and Pombar, 2021)**.

To benefit from physiological changes that may increase oxygenation through decreased Ventilation/Perfusion (V/Q) mismatch and lung injury, a patient is placed in a prone posture by lying face down on their anterior chest and abdomen. Gravitational pressures on the lung parenchyma allow for increased recruitment of the posterior zones, allowing a greater proportion of alveoli to engage in gas exchange, and expansion of the anterior chest wall is restricted, resulting in a more uniform chest wall compliance. In the prone position, the diaphragm exerts stress forces on the lungs more evenly, which may lessen lung damage during both mechanical ventilation and spontaneous breathing. **(Telias, Katira, and Brochard, 2020; Venus, Munshi, and Fralick, 2020)**.

Like the pregnant anatomy and physiology, the prone position is not contraindicated with pregnancy. Additionally, a cushion surrounding the uterus in pregnancy should be taken to unload the uterus and evade aortocaval compression, especially in late pregnancy **(Tolcher et al., 2020)**. Extraordinary attention ought to be paid to external fetal continuous hemodynamic monitoring during prone ventilation sessions. Also, the patient's responsiveness to prone positioning should be assessed closely via monitoring of arterial blood gases and oxygen saturation **(Ray and Trikha, 2018)**. Case reports suggested that pregnant women safely lying in a prone position may be very helpful in these patients because, when done properly, it can alleviate both aortocaval compressions from the gravid uterus and diaphragmatic compression from the abdominal contents. **(Tolcher et al., 2020).**

Special monitoring of pregnant patients in prone positions should be considered. Special importance should be given to fetal monitoring, Arterial Blood Gas (ABG) measurements ought to be made periodically. Patients are categorized as responders (PaO2:FiO2 ratio increases by 20% or by >20 mm Hg) or non-responders based on their ABG results. The response usually manifests during the first several hours, however, it might also take 12–16 hours. The patient should be returned to a supine position, and alternative rescue measures should be considered if prone ventilation fails (there is no improvement in gas exchange, lung mechanics, or cardiovascular status). In other studies, prone ventilation lasted anywhere between 6 and 8 hours per day and 16 and 20 hours per day **(Ray and Trikha, 2018).**

Pregnancy indicates specific precautions for patients when adopting a prone position. Furthermore, due to the large gravid uterus at advanced gestational ages, prone positioning for patients at 34 weeks of gestation or more may be more technically challenging, so the advantages and disadvantages of birth before PP should be carefully addressed. To offload the uterus and prevent aortocaval compression, extra attention must also be devoted to padding above and below the gravid uterus, especially in late pregnancy (i.e., beyond 24–28 weeks of gestation). Although there are commercially available cushions specifically designed for the gravid uterus, prone positioning can also be safely accomplished by employing the pillows and blankets that are readily available in the inpatient setting. Technically demanding fetal monitoring sessions in the prone position may be, yet continuous external fetal monitoring is advised after 24 weeks of gestation **(Bikash and Trikha, 2018).**

The prone positioning beneficial effects for ARDS were investigated in several clinical trials **(Guérin et al., 2013)**. However, pregnant women were excluded because of concern for fetal well-being. It was reported that ventilation in the prone position saved those patients by improving oxygenation **(Samanta, Samanta, Wig and Baronia, 2014)**. Recently, global anecdotal reports revealed that prone positioning may be particularly helpful for hypoxemic pregnant women **(Ray and Trikha, 2018; Tolcher et al., 2020)**. To maintain optimal obstetric practices and achieve favorable maternal and fetal outcomes, it is acknowledged that the help provided to pregnant women affected by the disease necessitates particular care measures **(Souto et al., 2020).**

Significance of the Study:

The estimated prevalence of ARDS in pregnancy has been reported to be 16–70 per 100,000, with high rates of fetal death and asphyxia. COVID-19 infection consequences are one of the leading causes of ARDS in pregnancy. The management of pregnant patients in intensive care units is challenging and requires special consideration of the physiological and anatomical changes in pregnancy, placental blood flow, and interactions of maternal-fetal circulation. Little is known about the effects of (PP) during pregnancy on the fetus, as pregnant patients are frequently excluded from trials (a practice recently challenged during the COVID-19 pandemic) **(Malinowski, Snelgrove, and Okun, 2020).** There is very limited evidence to guide the management of a pregnant patient with severe ARDS who requires prone ventilation **(Ray and Trikha, 2018)**. Furthermore, only anecdotal case reports were revealed for prone position ventilation use in pregnant patients. Hence, this study was conducted to search for this issue.

Aim of the study:

The study aimed to evaluate the effect of prone positioning on hemodynamic parameters among Pregnant Women with covid-19-related hypoxemia.

Study Hypothesis:

It was expected that the prone position will be effective to improve the hemodynamic parameters among pregnant women with covid-19-related hypoxemia evidenced by significant differences between the pre-test and the pot-test in favor of the post-test. As well as, shows differences in the visual analog scale for dyspnea and discomfort pre- and post-prone positioning.

Operational Definitions:

Hemodynamic Parameters: A standard diagnostic tool that describes intravascular pressure, oxygenation, and blood flow within the cardiovascular system including heart rate, systolic blood pressure, and diastolic blood pressure. In addition to, respiratory rate, Oxygen Saturation (SpO2), and arterial blood gases which indicated as a mechanism to assess the balance of oxygen delivery, and oxygen utilization.

Subjects and Method

Study design:

A quasi-Experimental pre-posttest Study design was utilized in the study.

Setting:

It was carried out at the ICU in Mansoura University Hospital, one of the isolation hospitals assigned to receive covid-19 patients. It contains 3 rooms each one had 4 beds equipped with the necessary equipment, high-flow supplemental oxygen, a Mechanical Ventilation machine, and Dixtal Multiparameter Monitor.

Sampling:

A purposive sample consisting of all recruited patients proven with COVID-19 was screened, and those who met the following criteria were deemed eligible:

- 20 and 35 years old with singleton uncomplicated pregnancies.
- Gestational age less than 34 weeks.
- Confirmed by positive reverse transcriptase polymerase chain reaction (RT-PCR) for SARS-CoV-2.
- Had chest computed tomography results indicative of COVID-19.
- Required oxygen supplementation.
- Wake patients who are breathing spontaneously.
- Hadn't any high-risk medical conditions.
- Able to communicate& cooperate during the procedure

The main exclusion criteria:

- Women who had an acute respiratory failure with hemodynamic instability/life-threatening arrhythmia.
- Non-reassuring fetal status.
- Spinal instability increased intracranial pressure
- Mechanically ventilated & requiring intubation and impaired consciousness.
- Who, according to the published ARDS literature, had anatomical restrictions to prone positioning (e.g., facial trauma, a pacemaker insertion, recent abdominal,

thoracic, or spine surgery, and pelvic fractures).

Sample size:

The G power program was used to estimate the sample size using the following data: effect size 0.5, α error prop 0.05, power (1-β err prop) 90 % using an independent t-test to detect the mean between two equal groups. The sample size was thirty-six participants.

Data Collection Tools:

The tool I: Structured Interviewing Questionnaire

Researchers developed it after reviewing the relevant publications **(Cavalcante et al, 2021).** It consisted of two sections:

Section 1: Demographic Characteristics & Anthropometric Data:

It was designed to obtain personal and anthropometric data Including age, occupation, level of education, residence, BMI, and smoking history.

Section 2: Obstetric History Related Data:

It consisted of questions regarding gravidities, parity, abortion numbers, and the current gestational age.

Tool II: Hemodynamic and Oxygenation Parameters Chart:

It was used to monitor the hemodynamic and oxygenation parameters of women and the fetus **(Aitken, Marshall, and Chaboyer, 2019; Morton and Fontaine, 2018)**. It was divided into two parts:

1st part: Maternal Hemodynamic Parameters (Bartolone et al, 2021) The following parameters were measured by using bedside cardiac monitoring included Heart Rate (HR), Oxygen Saturation (SpO2), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Respiratory Rate (RR) indices. The arterial blood gases were used to assess PH, partial pressure of arterial oxygen (PaO2), Partial pressure of arterial carbon dioxide (PaCO2), and (SaO2). Variation between timepoints of Supine Position (SP1) and (SP2) just before PP and within 3 hours after resupination.

2nd part: Electronic Fetal Heart Rate Monitoring chart:

It was used to assess fetal HR monitoring by using cardiotocography. It was reported as bradycardia if it was below 100 b/min and tachycardia if it was higher than 160 b/min.

Tool III: Visual Analog Scales for Dyspnea and Discomfort (VAS) adopted from Wilson and Jones (1989)

It was used to measure how the patient was tolerable in the prone position by measuring the dyspnea and discomfort level during the prone position. It is a horizontal line, 100 mm in length, and anchored by word descriptors at each end. The VAS anchored with no breathlessness or discomfort at 0 cm and maximum possible breathlessness or discomfort at 10 cm. Adverse events were monitored. The patient marked on the line the point that they feel representing the perception of their current feeling. The distance (mm) between the beginning of the horizontal line and this mark represents the degree of dyspnea perception. (0 represents no dyspnea or discomfort), (1-3 mild levels), (4-7 moderate levels), and (8-10 severe levels).

Validity &Reliability of study tools:

Three juries of academic professors in critical care and women's health and midwifery nursing revised the tools to assess the validity of the material and make sure that the intended meaning was being conveyed and that the suggested modifications and modulation were taken into consideration in accordance with their comments. Testing the reliability of the tool for dyspnea and discomfort scale using data from a pilot study (5 cases), and applying SPSS version 21; it was found that the Cronbach's alpha test for dyspnea scale = 0.929 and test-retest is r = 0.912. For the discomfort scale, the Cronbach's alpha = 0.960 and test-retest is r = 0. 811. This means good reliability and internal validity of both scales.

Pilot Study:

Four patients were comprised in the pilot study which represented 10% of the study sample to test the practicality and clarity of the developed tools, as well as assess the utility of the instruments and evaluate the time required to collect data. As a result, the necessary adjustments and alterations were done, and those women were excluded from the study sample.

Ethical Considerations:

The study was approved by the heads of both critical care nursing and women's health & midwifery departments as well as by the obstetrics and gynecology department at the university hospital in Mansoura. Ethical approval was obtained from the ethical committee of the faculty of nursing for conducting the study. Consequently, the consent of the study's participants was obtained. The confidentiality of the information and the participants' privacy were both ensured. Additionally, they were informed of their right to refuse or leave the study at any time and that they would not suffer any harm while it was being conducted.

Method:

- An official approval letter was attained from the director of Mansoura university hospital department as well as from the Ethics Committee at the Faculty of Nursing, Mansoura University to gain their authorization to carry out the research after an explanation of its aim and scientific context. Then, the researchers developed all tools after intensive reviewing of the relevant literature.
- Tools content validity has been tested by a jury of three professors in the field of critical care & obstetrics and gynecology nursing and one of the statistics fields. Tool III reliability has been tested using the Cronbach alpha, tools I &II didn't indicate a reliability test as it was in the form of quantitative continuous variables.
- The duration of data collection consumed 6 months starting from May 2021 to October 2021.
- The researchers assessed the availability of ICU personnel for repositioning by explaining the aim, the technique of PP, and the method of data collection to the ICU team (Min. 2 nurses per each patient) supervised by anesthesiology, high-risk obstetrics as the researchers were not allowed to implement the intervention by themselves as a result of precautionary measures in the isolation hospital.
- The number of patients ranged from two to three cases per week, it varies according to the flow rate and the clinical pictures and of cases in ICU till the total number of samples was completed.
- After obtaining the demographic, anthropometric, and obstetrics data of all the participants, the eligibility of all patients with confirmed COVID-19 was verified through screening.
- Following an explanation of the purposes of the study and technique, each woman who met the requirements to participate gave their official informed permission. The researchers underlined that the study's participants' involvement was completely voluntary, and data confidentiality was guaranteed, they were informed about their right to reject participation without any consequences.
- Once enrolled, baseline data were collected (timepoint SP1), hemodynamic parameters measurement, ABG, electronic fetal monitoring, and visual analog scale of dyspnea.
- Before (PP), NPO for at least one hour. Secure lines (folly, arterial, peripheral, central lines, and drains), confirm the oxygen delivery device is well connected, and increase the O_2 to the maximum setting. Move ECG leads to the back (mirror image).
- Then placing patients in (PP) for at least ≥3 hours (Lying the patient on their side facing the O_2 delivery device while placing padding, it was essential to prevent injuries by reducing pressure on the abdomen, providing support to pressure points, and keeping the head and abdomen free of compression with the use of large size boulders or pillows.
- To get oxygen, the patient was positioned with their side facing the oxygen source. Adjusting the bed to reverse Trendelenburg (~10°). The patients were turned on the pillow by the following technique: three at the head, two supporting the gravida uterus, two in the pelvis level (aligned with the symphysis pubis), and two under the knees.
- Support the patient while they squatted down between two pillows at the bottom (lower leg pillows were placed once she is prone and ensuring that their thighs rested on the pelvic pillows.
- The lower headrest of the bed (maintain reverse Trendelenburg). Adjust the padding to make

sure the patient is comfortable. Make sure the pregnant belly is not being compressed, and confirm all lines and tubes were not pressing against the skin. Readjusting the O_2 setting to the pre-prone position.

- Monitor the O_2 saturation after 15 minutes and continue for 2 hours if the saturation is ≥95 and no signs of breathing distress, monitor fetal heart rate during PP, discontinue PP if there was no improvement with the position change and the patient was unable to endure the position.
- Helping the patients position themselves supinely on the pillows and elevate the head of the bed.
- Hemodynamic parameters, ABG, electronic fetal monitoring, and visual analog scale of dyspnea were measured just before PP and within 3 hours after resupination. Then the results were compared.
- The data were tabulated and analyzed using descriptive and inferential statistical methods. The demographic variables were described using frequency and percentage.

Statistical analysis:

The acquired raw data was coded and calculated using SPSS Inc. version 21 before the statistical analysis was conducted. The quantitative variables (frequency and percentages) and mean SD of the data were reported (quantitative continuous variables). When comparing categorical variables, the Fisher exact test (FET) was employed instead of the chi-square test ($\chi 2$) if any cell's anticipated value was less than 5. At $P \leq 0.05$, the difference was deemed significant. Categorical variables were compared by using ($\chi 2$) test, while paired t-test was carried out for comparing the quantitative data. Pearson correlation coefficient (r) was calculated to estimate the correlation between two quantitative variables.

Results:

It shows that most of the study participants are in the age group ranging from 20-30 years old with Mean ± SD = 26.55 ± 4.12, around two-thirds, were working, less than one-third received high school & university education, and 61.1% of them were from rural areas. As regards BMI; 72.2% of them had an average weight and 27.8% were overweight, only 13.9% were practicing a smoking habit. Related to comorbid disease, (80.6) had neurological, (5.6%) respiratory, (8.3%) CVD, and (5.6%) GIT. Two-thirds (61.1%) received O2 supplementation either through a face mask or nasal cannula and its amount ranged from 1 -4 L/min. (table 1).

Table (2) shows that the gravidity of the studied women ranged 1-5 times, parity may be null (11.1%), once (36.1), twice (33.3%) and three (19.4%). Abortion was reported among 13.9%, which may be one or two. The gestational age was less than 28 weeks among 22.2% and from 28-33 weeks among (77.8%) with mean ± SD = 28.61 ± 3.99.

There was an improvement in most hemodynamic parameters' mean scores after prone positioning. There was a significant improvement (P<0.001) in the Peripheral oxygen saturation, PH, Arterial oxygen saturation, and PaO_2. Also, there was a significant decrease in the average measurement of Respiratory Rate, $PaCO_2$, PaO_2/FiO_2, and heart rate. While HCO3 and blood pressure showed no significant changes (>0.05) (Table 3).

Table (4) showed a significant average and percent of hemodynamic and oxygenation parameter changes. For example, the average percent decrease in respiratory was 18.1% and the average percent increase in PaO_2 was 67.91%.

The average fetal heart rate was significantly decreased from 165.25 ± 18.10 beats/minute to 148.97±14.47 beats/minute after prone positioning (table 5).

There was a significant improvement in dyspnea levels after lying in the prone position; the moderate and severe dyspnea levels decreased from 58.3% to only 8.3% and reported no dyspnea after lying in the prone position. Also, there was a significant improvement in discomfort level after the prone position; mild, moderate, and severe discomfort showed a significant decreased and 25.0% reported no discomfort after the prone position.

Figures (1) show that there is a positive significant strong (r = 0.924, P<0.001) correlation between dyspnea and discomfort level before practicing prone positioning.

Table (1): Frequency and distribution of the demographic Characteristics of the studied women

Characteristics	No (36)	%
Age (years)		
- 20-	14	38.9
- 25-	16	44.4
- 30-35	6	16.7
	Mean ± SD = 26.55 ± 4.12 Min-max:20-35	
Working status:		
- Housewife	12	33.3
- working	24	66.7
Educational level:		
- Illiterate	5	13.9
- Primary	9	25.0
- High school	10	27.8
- University	8	22.2
- Postgraduate	4	11.1
Residence:		
- Urban	14	38.9
- Rural	22	61.1
BMI:		
- Average	26	72.2
- Overweight	10	27.8
Smoking:		
- Yes	5	13.9
- No	31	86.1
Medical history (Comorbid disease):		
- Neurological	29	80.6
- Respiratory	2	5.6
- CVDs	3	8.3
- GIT	2	5.6
O2 supplementation methods:		
- On room air	14	38.9
- Face mask	21	58.3
- Nasal cannula	1	2.8
Amount of O2 (L/min) (22)		
- One liter	3	13.6
- Two liters	10	45.5
- Three liters	7	31.8
- Four liters	2	9.1

Table (2): Frequency and distribution of Obstetric history of the studied women

Characteristics	No (36)	%
Gravidity		
- Primary	4	11.1
- Second	11	30.6
- Third	13	36.1
- Fourth	6	16.7
- Fifth	2	5.6
Parity:		
- Nulliparous	4	11.1
- One	13	36.1
- Two	12	33.3
- Three	7	19.4
Abortion:		
- Yes	5	13.9
- No	31	86.1
A number of abortions (5):		
- Once	3	60.0
- Twice	2	40.0
Current gestational age:		
- < 28 weeks	8	22.2
- 28 – 33 weeks	28	77.8
	Mean ± SD = 28.61 ± 3.99 Min-Max: 18-33	

Table (3): Hemodynamic and oxygenation parameters mean scores of the studied women before and after prone positioning

Hemodynamic &oxygenation parameters	Before	After	Significance test (t-test)
	Mean ± SD	Mean ± SD	
Respiratory Rate (RR) 16-20 C/min	23.19 ± 3.52	18.81 ± 2.11	10.399, P<0.001
Peripheral oxygen saturation (SPO_2)95%-99%	85.36 ± 5.77	93.56 ± 2.65	10.404, P<0.001
PH 7.35-7.45	7.34 ± 0.10	7.40 ± 0.05	4.654, P<0.001
$PaCO_2$35-45 mm Hg	40.70 ± 8.43	34.01 ± 7.56	7.136, P<0.001
HCO_3 22-26	22.59 ± 4.72	22.54 ± 5.07	0.079, P 0.937
Arterial oxygen saturation (SaO_2)95%-100%	69.43 ± 15.93	89.51 ± 10.07	7.648, P<0.001
$PaO_2$80-100 mm Hg	45.86 ± 15.06	72.48 ± 18.27	8.985, P<0.001
PaO_2/FiO_2~ 400-500 mmHg	93.36 ± 8.70	81.28 ± 9.23	8.005, P<0.001
Heart Rate (HR) 60-90 b/min	93.08 ± 8.86	80.97 ± 9.04	8.053, P<0.001
Systolic Blood Pressure (SBP)100-140 mm Hg	119.33 ± 10.85	119.19 ± 6.27	0.077, P 0.939
Diastolic Blood Pressure (DBP)60-90 mm Hg	79.31 ± 8.80	79.39 ± 5.32	0.060, P 0.952

Table (4): Hemodynamic and oxygenation parameters mean score average & percent changes among the studied women

Hemodynamic &oxygenation parameters	Changes	Average changes	Average Percent changes
		Mean ± SD	Mean ± SD
Respiratory Rate (RR) 16-20 C/min	↓	4.39 ± 2.53	18.10 ± 8.69
Peripheral oxygen saturation (SPO_2)95%-99%	↑	8.19 ± 4.73	10.01 ± 6.93
PH 7.35-7.45	↑	0.92 ± 1.22	0.07 ± 0.08
$PaCO_2$35-45 mm Hg	↓	6.69 ± 5.62	15.92 ± 12.69
Arterial oxygen saturation (SaO_2)95%-100%	↑	20.08 ± 15.75	36.53 ± 42.83
$PaO_2$80-100 mm Hg	↑	26.63 ± 17.78	67.91 ± 54.19
PaO_2/FiO_2~ 400-500 mmHg	↓	12.08 ± 9.06	12.70 ± 8.87
Heart Rate (HR) 60-90 b/min	↓	12.11 ± 9.02	12.74 ± 8.82

Table (5): Fetal heart rates mean scores before and after prone positioning

Fetal heart rate	Before	After	Significance test (t-test)
	Mean ± SD	Mean ± SD	
Fetal heart rate	165.25 ± 18.10	148.97 ± 14.47	10.035, P<0.001

Table (6): Frequency and distribution of dyspnea and discomfort level among the studied women before and after prone positioning

Dyspnea Level	Value	Before		After		Significance test χ^2
		No	%	No	%	
No dyspnea	0	1	2.8	13	36.1	25.061, <0.001
Mild	1-3	14	38.9	20	55.6	
Moderate	4-6	18	50.0	3	8.3	
Severe	7-9	3	8.3	0	0.0	
Maximum dyspnea	10	0	0.0	0	0.0	
Discomfort Level						
No discomfort	0	0	0.0	9	25.0	10.941, 0.012
Mild	1-3	19	52.8	15	41.7	
Moderate	4-6	12	33.3	10	27.8	
Severe	7-9	5	13.9	2	5.6	
Maximum discomfort	10	0	0.0	0	0.0	

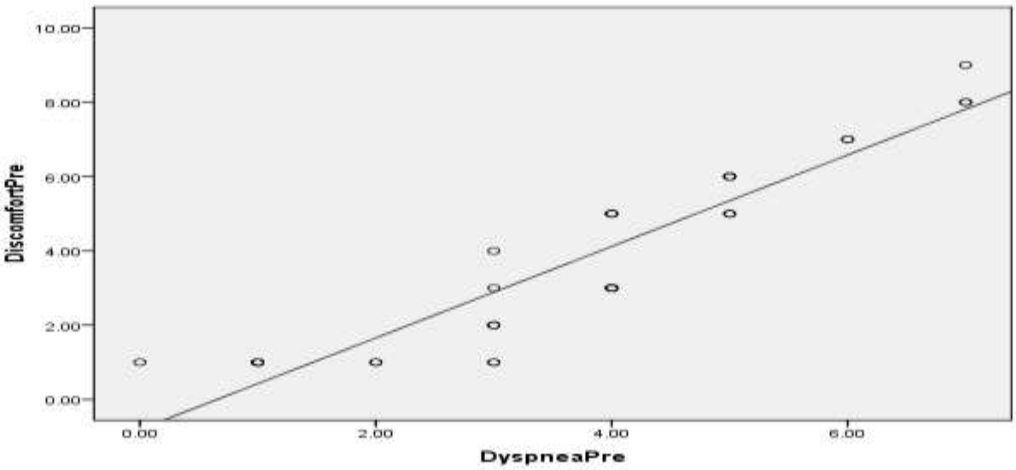

Figure (1): Correlation between dyspnea and discomfort levels before prone positioning

Discussion

Coronavirus Disease 2019 (COVID19) is caused by the Severe Acute Respiratory Syndrome Coronavirus2 (SARSCoV2) which can result in respiratory failure, multiorgan dysfunction, and death **(Solomon, Berlin, Gulick, and Martinez, 2020).** There is growing interest in prone positioning as a therapy for severe COVID- 19 **(Weiss et al., 2021).** The current study aimed to evaluate the effect of prone positioning on hemodynamic parameters among pregnant women with COVID-19-related hypoxemia. According to current research findings, the aim was accomplished by employing the study's hypotheses as references which revealed that there was a statistically significant difference between pre-and post-test results in favor of post-intervention. So that the findings of the present study supported the research hypothesis.

The study results revealed improvement in most hemodynamic parameters after PP, there was a significant increase in the mean score of peripheral oxygen saturation, PH, Arterial oxygen saturation, and PaO_2. Also, there was a significant decrease in Respiratory Rate, $PaCO_2$, PaO_2/FiO_2 and heart rate mean score. This finding is correlated with the scientific base that physiologically, a prone position is believed to reduce abdominal and mediastinum compression, improve V/Q mismatch, and lessen atelectasis of the dorsal lung areas. This was supported by **Ng, Tay, and Ho, (2020)** who reported that prone positioning is thought to improve ventilation-perfusion matching by decreasing lung compression caused by mediastinal structures and boosting dorsal lung aeration. Similarly, **Prabawa, Silakarma, and Susantio (2021)** found that PP among COVID-19 patients improved oxygenation. Higher oxygen saturation, the PaO2/FiO2 ratio, the SaO2/FiO2 ratio, the ROX index, and a decline in respiratory rate, work of breathing, shortness of breath, intubation, and mortality rate were all indicators of improved oxygenation.

In addition, **Jha et al., (2021)** who investigated the physiological effects and subjective tolerability of prone positioning in COVID-19 and healthy hypoxic challenge, reported that prone positioning in COVID-19 patients resulted in a small but significant increase in SpO2, with an improvement apparent within 10 min. As well **Lindahl, (2020)** clarified that the exponential growth of COVID-19 infection resulted in moderate to severe hypoxia that would need oxygen supplementation, resulting in a medical oxygen deficiency. Prone positioning improved oxygenation by reducing lung compression and increasing lung perfusion. Changes in the flow of extravascular lung fluid and discharges are also important. It also lowered alveolar distension, minimizing ventilator-associated lung damage and facilitating the recovery of collapsed alveoli during supine ventilation.

Another study conducted by **Guérin et al., (2013)** emphasized that when PP is used correctly, it has no negative consequences on the pregnant female's hemodynamics and may even enhance them due to its beneficial effects on the cardiac and pulmonary systems, making it critical to maintain venous return when employing this approach. Also, **Wiersinga, Rhodes, Cheng, Peacock, and Prescott., (2019)** highlighted those patients with acute respiratory problems are typically treated prone because it lowers mortality and improves the arterial partial pressure of oxygen (PaO2)/inspiratory oxygen fraction (FiO2) (PF) ratio.

A study carried out by **Oliveira, Lopes, Rodrigues, Zugaib, and Francisco, (2017)** conducted a randomized controlled trial on 33 pregnant women to study the effect of the prone position compared to other positions such as fowler and lateral position revealed considerable improvement in respiratory rate, oxygen levels, and fetal heart parameters in prone-positioned pregnant women. Also, it was reported that the women's respiratory rates did not significantly change when they switched from FP to PP. (p=0.319), but there was a significant difference when they shifted from LL2 to PP2 (p=0.031). On the contrary **Elharrar et al., (2020)** conducted a prospective study among awake, non-intubated, spontaneously breathing patients with COVID-19 and hypoxemic acute respiratory failure and reported there was no discernible difference between Pao2 before PP and Pao2 following resupination (*P* = .53).

The current study findings revealed that the fetal heart rate mean scores were significantly decreased to normal ranges. These findings are supported by **Tolcher et al., (2020)** who emphasized that constant external fetal monitoring is indicated once the gestation reached 24 weeks, even if it could be logistically difficult to examine the fetus when in the prone position. As regards the dyspnea and discomfort level, there was a significant improvement in dyspnea levels after and the discomfort level post-intervention after lying in the prone position. Also, there was a positive significant strong correlation between dyspnea and discomfort level before practicing prone positioning, this result may be attributed to the prone position helps in relieving pressure from the diaphragm which allows easy respiration, full lung expansion, and maximum levels of gas exchange within the lung. Also, it has a positive proactive effect in improving ventilation-perfusion corresponding in those patients with respiratory disorders by reducing the compression of the lung and improving dorsal lung aeration.

In the same line study conducted by **Schnettler, Al Ahwel, and Suhag, (2020)** entitled the effect of prone position in severe ARDS in COVID-19 infected pregnancy. It was reported that PP was approved to be particularly helpful for patients with COVID-19 who had moderate or severe respiratory disease. pregnant women may be safely lying in a prone position and it may be especially effective in these patients due to its ability to relieve diaphragmatic compression caused by abdominal contents as well as compression caused by the gravid uterus, which relieves breathlessness and discomfort if used correctly. Padding above and below the gravid uterus should also be properly considered to offload the uterus and minimize aortic compression. Similarly, reported that the prone position had a satisfactory effect on oxygenation parameters in COVID-19 patients, reducing ventilation/perfusion mismatch and hypoxemia. The prone position reduces the pleural pressure differential between the dependent and nondependent lung areas due to gravity influences and structural shape matching of the lung with the thoracic cavity. These findings are thought to result in more homogenous lung aeration and tension distribution, improving dorsal lung region recruitment. This may reduce breathing effort, and stabilize heart rate.

The study was associated with some limitations, such as the lack of a comparison group and generalizability of the research findings due to the small sample size may not necessarily be representative of the general population. Some cases could not tolerate the prone positioning implementation, so it was discontinued. Those participants were excluded from the study as well as identifying placental circulation abnormality, fetal monitoring is crucial. Additionally, a single episode of (PP) was studied, the follow-up was brief, medical consequences were not evaluated, and the causality of the observed changes cannot be deduced. Invasive mechanical ventilation was necessary for six patients. Four of them were replaced by other patients after failing to maintain PP for an hour or longer and necessitating intubation within 72 hours.

Conclusion

The current study findings highlighted that implementing the prone position had a highly statistically significant effect on improving the hemodynamic parameters and decreasing dyspnea and discomfort levels among pregnant women with COVID-19-related hypoxemia as well as the fetal heart rate.

Recommendations:

In light of the study findings, it is suggested to use the prone position in pregnancy as a method of clinical management for pregnant patients infected with COVID-19-induced hypoxemia.

Further studies evaluating the prone position's impact on reducing overall morbidity during pregnancy are needed. Large-scale studies in different ICUs in many hospitals are needed to provide strong evidence about the effectiveness of the prone position in non-intubated and intubated pregnant patients infected with COVID-19.

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Conflict of interest

There were no stated conflicts of interest by the authors.

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