CLINICAL SCIENCE OF NUTRITION
Original Article
DOI: 10.62210/ClinSciNutr.2024.97

Does prone positioning affect achievement of medical nutritional goals?

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Cite this article as: Öztürk Selçuk S, Arslan M, Özel Bilgi D, Yılmaz R, Çukurova Z. Does prone positioning affect achievement of medical nutritional goals?. *Clin Sci Nutr*. 2024;6(3):137-143.

ABSTRACT

Objective: Prone position (PP) is used in the treatment of severe acute respiratory distress syndrome (ARDS). The aim of our study was to evaluate the effect of PP (>24 hours) on achieving medical nutritional goals.

Materials and Methods: Between 2018 and 2022, a total of 385 patients in the Anesthesiology and Reanimation Intensive Care Unit (ICU) were included, 183 of whom were in the prone group and 202 in the Non-prone (NP) group, who underwent Invasive Mechanical Ventilator (IMV) support with ARDS. Demographic data, comorbidities and medical nutrition (MN) status of the patients were analysed retrospectively from the electronic database. The rate of achievement of MN targets on days 3.7.14 of the PP and NP groups was compared.

Results: A statistically significant low level negative correlation was found in the correlation analysis between prone time and the rate of achievement of calorie and protein targets in the PP group patients (r=-0.370, p<0.001) (r=0.303, p<0.001). The rate of severe ARDS was statistically significantly higher in the PP group than in the NP group (P<0.001). The median duration of IMV in both patient groups was over 15 days and was statistically significantly higher in the PP patient group (p<0.001).

Conclusion: PP delays the achievement of the target calorie and protein ratio, and some patients did not reach the target calorie and protein ratio.

Keywords: Prone position, ARDS, calorie target, protein target

INTRODUCTION

In acute respiratory distress syndrome (ARDS), high dose vasopressor intake, pron position (PP) and interruption or reduction of enteral nütrition(EN) due to gastrointestinal symptoms (regurgitation, diarrhoea, etc.) cause nutritional deficiency.[1] PP is frequently applied in the treatment of ARDS. Recently, studies have suggested that when initiated early and applied for a long period, PP might reduce mortality in selected patients with severe ARDS.[2] PP causes regurgitation and increase in GRV (gastric residual volume) due to increased intra-abdominal pressure.[3] Patients receiving invasive mechanical ventilation in PP exhibit a number of factors associated with impaired gastric motility, including high-dose sedation, high Simplified Acute Physiology Score II (SAPS II) and Sequential Organ Failure Assessment (SOFA) score values, flat position without head elevation, which may increase the risk of EN intolerance.[2]

International guidelines recommend the initiation of low-calorie EN in the first 48 hours, except in cases of shock, hypoxaemia and acidosis.[4,5] In standard practice, medical nutrition (MN) is interrupted until haemodynamics are stable, but recent clinical studies have shown that early MN reduces the risk of infection, morbidity and mortality rates and shortens the duration of hospital stay.[6] According to the guidelines, paranteral nütrition(PN) is recommended

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Received: May 13, 2024 Accepted: October 14, 2024
Published: December 7, 2024

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in cases where EN cannot be applied (after abdominal surgery, GIS intolerance, etc.) and the target calorie-to-protein ratio of 60% cannot be reached.[7] According to Intensive Care guidelines, it is recommended that MN, which provides up to 70% of the target calorie requirement in the early period of acute illness, should be given in the first three days with a gradual increase, and should be given up to 80%-100% after the third day to limit the risk of overfeeding and refeeding syndrome. In parallel with this, protein can be gradually increased to 1.3 g/kg/day.[8]

This study was designed to examine the efficiency and effectiveness of EN support in patients receiving mechanical ventilation in the PP position, in comparison with the same patients in the supine position.

MATERIAL AND METHOD

Study Design and Patient Population

Patients receiving inpatient treatment in the intensive care unit (ICU) between 1 March 2018 and 31-March 2022, diagnosed with ARDS according to the 2012 Berlin Criteria and receiving invasive mechanical ventilator (IMV) support were included in our study. Our study was a retrospective, single-centre observational study.

Our study was approved by the Ethics Committee of Health Sciences University Bakırköy Sadi Konuk Training and Research Hospital with the decision number 2023/251 dated 05.06.2023 after the approval of the Republic of Turkey Ministry of Health Clinical Research Board form.

Data Sources and Measurements

Patient data registered in Metavision/ Qlin ICU Clinical Decision Support Software in the Intensive Care Unit of the Anaesthesia and Reanimation Clinic were obtained by Structured Query Language (SQL) queries.

Data on ICU admission SOFA, APACHE-II, m-NUTRIC scores, demographic data, comorbidities, need for CRRT, need for ECMO, PaO2/FiO2 ratio, duration of intensive care unit stay (LOS), duration of IMV, total amount of norepinephrine support, MN type (EN, PN), number and duration of PP, and type of discharge from ICU were obtained retrospectively.

All patients included in the study were ARDS patients and were placed in the prone position when the P/F ratio was below 150.

Height and weight measurements of all patients followed up in the ICU were made during hospitalisation and entered into the system.

Daily medical nutrition targets of patients with body mass index (BMI) <30 kg/m2 were determined according to ideal body weight (IBW), and daily medical nutrition targets of patients with BMI ≥30kg/m2 were determined according to adjusted body weight (ABW).

IBW: In women = 45.5+2.3*((height/2.54)-60))

For men = 50+2.3*((height/2.54)-60)) and
ABW IBV+0.33*(Kilo-IBW)

The daily basal metabolic calorie needs of the patients were calculated by calculating the Harris Benedict and Schofield equations separately and taking the average. The daily protein target for these patients was determined as 1.3 g/kg. The realisation rates of the 3, 7 and 14-day calorie and protein targets of the patients were obtained from Metavision/ Qlin ICU Clinical Decision Support Software' data by Structured Query Language (SQL) queries.

Enteral Nutrition Protocol

Standard EN algorithms prepared according to current guidelines are applied in our clinic. One nurse follows a maximum of two patients and one nurse follows one patient in severe ARDS. The EN algorithm in our clinic uses the maximum tolerance minimum tolerance evaluation time logic and the algorithm aiming to get the maximum level of EN. EN is given with digital pumps spread over a standardised 24-hour time period. Initiation protocols with EN logic are monitored by clinical electronic decision support. The nutrition protocol applied in our clinic is shown in Figure 1.

The primary aim of our study was to evaluate the difference in achievement of 3, 7 and 14-day medical nutritional goals in patients who were and were not placed in the pronated position.

Secondarily, we aimed to compare both groups in terms of duration of stay on mechanical ventilator, follow-up time in intensive care unit and mortality.

Main Points

- In our article, we aimed to investigate the effect of the prone position on nutritional adequacy.
- We did not reach the protein and calorie targets in either group.
- A statistically significant low level negative correlation was found in the correlation analysis between prone time and the rate of achievement of calorie and protein targets in the PP group patients.

Statistical Analyses

Statistical analysis was performed using "IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA)". Frequency, percentage, median and interquartile range were used as descriptive statistics. Pearlson chi-square, Continuty correction and Fisher's exact test were used for comparison of qualitative data. Kolmogorov-Smirnov test was used to evaluate the normality of the distribution of quantitative variables. Mann Whitney U test was used for comparison of quantitative variables. Spearman's correlation test was used to evaluate the correlation between the duration of prostration and achievement of calorie and protein targets in the prone group. A P value <0.05 was considered statistically significant.

RESULTS

A total of 385 patients diagnosed with ARDS and receiving IMV support for at least 72 hours were included in the study, 183 of whom underwent PP (>24 hours) and 202 of whom did not undergo pron positioning. The rate of achievement of MN targets (calorie and protein) was retrospectively analysed. The flow chart of the study is shown in Figure 2.

The rates of chronic kidney disease (CKD), malignancy and chronic cardiac disease (CCD) were statistically lower in the PP group than in the nonprone group (p=0.004;0.036;0.07)

Table 1. Demographic and clinical characteristics of the patients

	NON-PRONE (n:202)	PRONE (n:183)	P
Prone time, (h) median (IQR)	-	97(60-162)	-
Age, median (IQR)	68(52-78)	57(46-65)	<0.001*
Men, n (%)	111(55)	117(63.9)	0.073
BMI, median (IQR)	27.4(24.2-31.0)	27.7(25.9-30.9)	0.119
ARDS type, n (%)			<0.001*
CARDS	46(22.8)	150(82)	
NONCARDS	156(77.2)	33(18)	
PaO2/FiO2, median (IQR)	174(113-255)	104(80-160)	<0.001*
Comorbidity, n (%)			
Diabetes mellitus	50(24.8)	47(25.7)	0.834
Hypertension	69(34.2)	59.9(31.1)	0.530
CCD	43(21.3)	26(14.2)	0.070
CKD	25(12.4)	7(3.8)	0.004*
COPD	17(8.4)	14(7.7)	0.930
CVD	10(5)	5(2.7)	0.390
Malignity	13(6.4)	3(1.6)	0.036*
Thyroid Disorders	4(2)	4(2.2)	1.000
APACHE-II, median (IQR)	22(16-28)	21(16-26)	0.451
SOFA, median (IQR)	9(7-12)	9(7-11)	0.443
m-NUTRIC, median(IQR)	5(4-7)	5(4-6)	0.012
Total NE (mg), median (IQR)	194(119-361)	159(80-240)	0.002
CRRT use, n (%)	86(42.6)	77(46.9)	0.836
ECMO use, n (%)	11(5.4)	27(14.8)	0.004*
MV time (days), median (IQR)	15.2(11.7-20.8)	18.2(14.3-22.9)	<0.001
LOS in ICU (days), median (IQR)	20.4(16.8-26.4)	21.1(17.1-26.4)	0.445
In ICU survival, n (%)	80(39.6)	86(47)	0.144

BMI: Body Mask Index, LOS: Length of intensive care stay, ARDS: Acute Respiratory Distress Syndrome, CARDS: COVID-19 ARDS, CCD: Chronic Cardiac Disease CKD: Chronic Renal Failure, COPD: Chronic Obstructive AC Disease, CVD: Cerebro Vascular Disease, *p<0.05

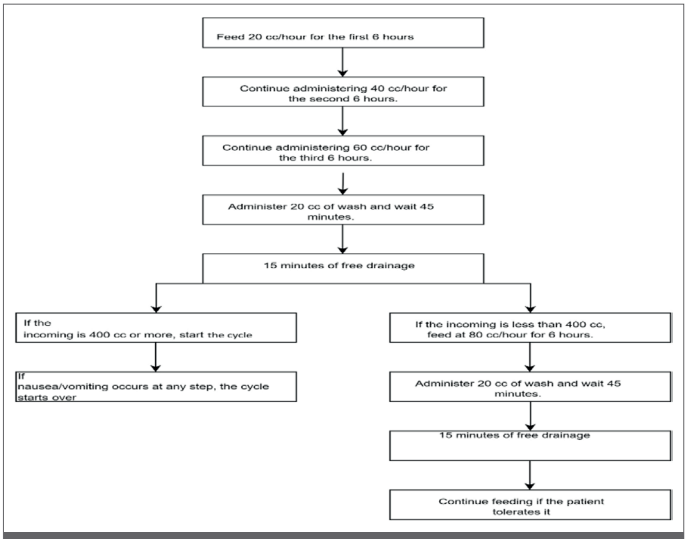


Figure 1. The enteral nutrition protocol established in our clinic according to ASPEN and ESPEN guidelines

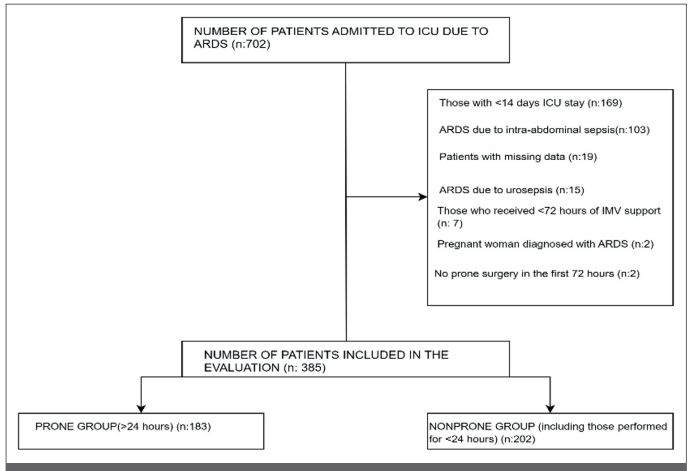


Figure 2. Patient selection and study design

Total norepinephrine (NE) utilisation rate was statistically lower in the PP patient group compared to the NP group (p=0.002). The m-NUTRIC score values were statistically lower in the PP patient group compared to the NP group (p=0.012). APACHE-II and SOFA scores at ICU admission were similar in both groups (Table 1). CARDS (Covid ARDS) patients comprised 82% of the PP group and 22.8% of the NP patients (p<0.001). The proportion of patients with severe ARDS was statistically significantly higher in the PP group than in the NP group (P<0.001). Median duration of IMV was over 15 days in both patient groups and was statistically significantly higher in the PP patient group (p<0.001). The rate of ECMO use for IMV support was statistically higher in the PP patient group than in the NP group (p=0.004).

There was no statistically significant difference between both groups in terms of EN and combined EN-PN utilisation rates (p>0.05). In PP group patients, the target calorie ratio for 3, 7 and 14 days (target calorie ratio 0.5-0.7 for the first 3 days and 0.8-1.0 for the following days) could not be reached. In addition, the rate of administered of the first 7 and 14-day calorie target in PP group patients was statistically significantly lower than NP (p<0.001).

In both groups, the rates of realisation of the 3, 7 and 14-day target calories were quite low. The rate of administered of the first 7 and 14-day protein target was also statistically significantly lower in the PP group than in the NP group (p=0.001; 0.011) (Table 2).

In the correlation analysis performed between prone time and the rate of administered of calorie target in PP group patients, a statistically significant low level negative

Table 2. Medical nutrition of the patients

	NON-PRONE (n:202)	PRONE (n:183)	P
Nutrition Type			0.261
EN	142(70.3)	138(75.4)	
Combine EN-PN	60(29.7)	45(24.6)	
Nutritional intake, median (IQR)			
-Calorie intake			
First 3 days	0.45(0.18-0.72)	0.37(0.24-0.56)	0.107
First 7 days	0.75(0.46-1.00)	0.47(0.36-0.74)	<0.001*
First 14 days	0.83(0.62-1.09)	0.61(0.47-0.85)	<0.001*
-Protein intake			
First 3 day	0.29(0.11-0.47)	0.25(0.16-0.42)	0.836
First 7 day	0.47(0.27-0.67)	0.37(0.24-0.52)	0.001*
First 14 day	0.53(0.38-0.74)	0.47(0.35-0.62)	0.011*

EN: Enteral Nutrition, PN: Parenteral Nutrition, *p<0.05

correlation was found between the increase in prone time and the administered of calorie target (r=-0.370, p<0.001) (Graph 1).

Again, in the correlation analysis performed between the prone time and the rate of administered of the protein target in the PP group patients, a statistically significant low level negative correlation was found between the prone time and the rate of administered of the protein target (r=0.303, p<0.001) (Graph 2).

DISCUSSION

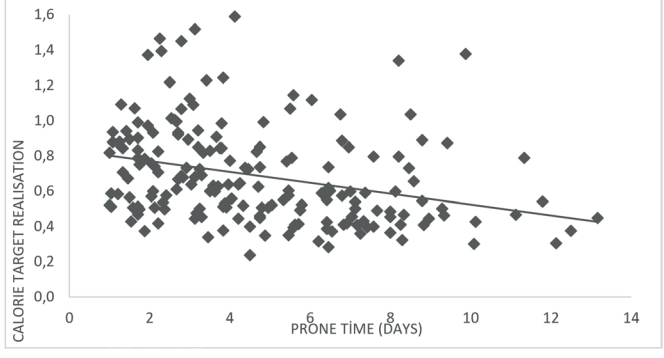
In the updated ARDS diagnosis and treatment guideline published by ESICM in 2023, prone position is strongly recommended in the treatment as in the previous guideline. Although the application of IMV in ARDS patients is life-saving, the application of PP prevents the early and desired level of EN in patients. The EN products recommended in the guidelines and currently available make it difficult to reach the recommended calorie and protein targets due to risks such as gastrointestinal tolerance of standard clinical nutritional protocols, regurgitation and pulmonary aspiration.[9]

According to the guidelines, nutritional support should be initiated in the first 48 hours in patients with inadequate oral intake. EN was started in the first 48 hours in both study groups. Patients who could not receive adequate EN (less than 50% of the basal calorie requirement) were given additional PN treatment as recommended by the guidelines.[4,10] The EPaNIC study does not recommend combined MN (EN+PN) in the first 3 days of ICU hospitalisation. Although it is not known precisely when combined MN should be started, it has been shown that delaying PN until day 8 has a favourable effect on ICU survival.[11]

The rate of reaching the calorie target in the PP patient group is considerably lower than in the NP patient group. In the PP group, the rate of reaching calorie and protein targets decreased with increasing prone time. In a prospective study conducted by Reignier et al. similar to our study, it was concluded that the target calorie-protein ratio decreased with increasing prone time.[12] In many studies evaluating medical nutritional targets in critical illness, similar to the results of our study, only 50-87% of the targeted EN can be achieved in critically ill patients.[13]

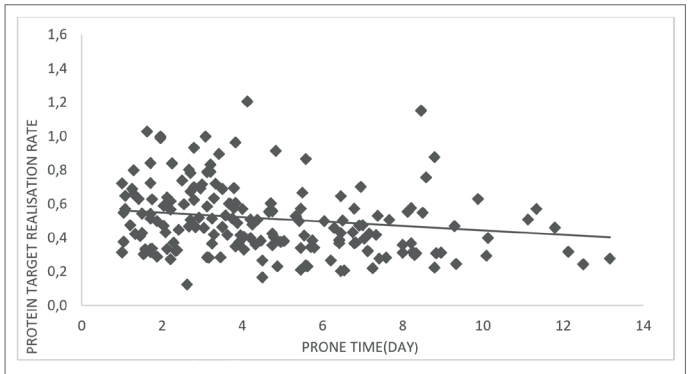
The daily target protein ratio was not reached in both patient groups. The rate of achieving the 7- and 14-day protein target was also lower in the PP group than in the NP group. IMV support in critically ill patients makes EN more difficult. In the ESPEN-2023 guideline, daily protein support of 1.3 mg/kg/day is targeted in critically ill patients.[8] According to the ESPEN 2021 guideline, hypocaloric (<70% calorie) nutrition is recommended in the early phase of the acute phase of the disease (first 2 days) according to the basal metabolic calorie requirement, while isocaloric (80-100%) nutrition is recommended in the later period.[5] In the NUTRIREA-3 study, similar to our results, the target calorie and protein ratio could not be reached.[12] In the prospective multicentre cohort study of Matejovic et al. 61.2% of the target calorie ratio and 57.6% of the target protein ratio could be reached, while patients hospitalised in the ICU should reach 80-100% of the target calorie-protein ratio.[14] In a study conducted by Mehta et al. in India, they concluded that MN was not a supportive treatment but a form of treatment and adequate amount of MN favourably affected the prognosis of the patient and shortened the duration of hospital stay.[15]

El Koofy et al. showed in a prospective study that high carbohydrate intake increased the carbon dioxide ratio and prolonged the duration of IMV support.[16] Similar



Spearman correlation analysis, r:0.37, p<0.001

Graph 1. Correlation analysis of the duration of prone position and the rate of realisation of calorie target



Spearman correlation analysis, r:30, p<0.001

Graph 2. Correlation analysis between duration of prone position and protein target administered rate

results were obtained in another retrospective study by Liposky and Nelson in critically ill patients with a high calorie goal.[17] Retrospectively, it was concluded that MN was important in the duration of stay in the intensive care unit and recovery of patients hospitalised in the ICU and discharged with healing.[15,17] In different studies, additional protein intake and high protein target did not have a favourable effect on clinical outcomes and lower doses of protein were recommended.[16] In a prospective study conducted by Mesejo et al., no significant difference was observed in terms of complications and mortality between both groups when standard EN and high protein EN were compared.[18]

Despite the limited number of patients in our study, no statistically significant difference was found between PP and NP groups in terms of mortality. In a multicentre prospective randomised multicentre study by Reignier et al., standard MN and calorie-protein restriction was compared in patients receiving IMV support, and it was found that the recovery time of patients receiving calorie-protein restriction was shortened, the complication rate decreased, but it did not affect mortality.[13] In a prospective randomised study conducted by Braunschweig et al., two groups receiving standard MN and two groups receiving high MN were compared and the study was stopped because of the high mortality rate in the group receiving high calorie-protein. It is recommended that it is appropriate to keep the target calorie and protein ratio <75%.[19] Therefore, guidelines recommend that the target calorie and protein intake should be achieved gradually.[5]

Zusman and Weijs found that MN supplementation should be given at 70-80% of the basal metabolic rate, and lower or higher supplementation increased the mortality rate.[20] When many studies conducted between 1966 and 2015 were analysed, no effect of protein ratio on mortality was shown.[21]

Cinel et al. showed in their study on the relationship between m-NUTRIC score and mortality that approximately 60% of patients hospitalised in the ICU and receiving IMV support were at risk for MN and m-NUTRIC score was associated with 28-day mortality.[22] In our study, m-NUTRIC score was statistically lower in the PP group compared to the NP group and no difference was found between the mortality rates in both groups.

The first 14-day total norepinephrine level, which is an indicator for haemodynamic instability that may require interruption of enteral nutrition, was statistically lower in the PP group than in the NP group. Despite this, medical nutrition targets were further behind in the PP group. In our clinic, EN is interrupted in patients with severe circulatory disorders and norepinephrine doses above 0.5mcg/kg/h as recommended in the guidelines. Weimann et al. found that EN tolerance decreased in patients receiving vasopressor support and calorie and protein targets could not be achieved. However, they recommend that EN should be continued even at low doses.[23]

However, the duration of IMV was statistically higher in the PP group than in the NP group. These clinical outcomes are probably due to the severe CARDS etiopathogenesis, which constituted a large proportion of the PP group (82%) and required ECMO support in more of our patients. In addition, as in our study, there are also studies showing that the duration of IMV is prolonged in the prone group due to the fact that falling behind in MN targets leads to an increased risk of malnutrition and sarcopenia.[24]

The most important disadvantages of our study were that it was retrospective, conducted in a single centre, and the daily basal calorie requirement was calculated by the average of Harris Benedict/Scholfield formulas, not by indirect calorimetry. In addition, due to the retrospective nature of the study, anthropometric measurements could not be performed and records related to GRV were insufficient.

CONCLUSION

Although PP improves lung ventilation and oxygenation parameters, it negatively affects the achievement of MN targets. Patients who will undergo PP should be followed up more closely considering that they may be malnourished.

Ethical approval: The study was approved by the Ethics Committee of Health Sciences University Bakırköy Sadi Konuk Training and Research Hospital (2023/251 / 05.06.2023).

Informed consent: Written informed consent was obtained from all patients who participated in this study.

Author contributions: Design – S.Ö.S.; Supervision – M.A., D.Ö.B., R.Y., Z.Ç.; Resources – S.Ö.S., D.Ö.B., R.Y.; Materials – S.Ö.S., D.Ö.B., R.Y.; Data Collection and/or Processing – S.Ö.S.; Analysis and/or Interpretation – S.Ö.S.; Literature Search – S.Ö.S..; Writing Manuscript – S.Ö.S.; Critical Review – M.A., D.Ö.B., R.Y., Z.Ç.

Funding: The authors declare the study received no funding.

Conflict of interest: The authors declare that there is no conflict of interest.

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