Impact of high fat low carbohydrate enteral feeding on weaning from mechanical ventilation

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Received 10 May 2014; accepted 8 July 2014
Available online 27 August 2014

KEYWORDS
Respiratory failure; Nutritional support; Mechanical ventilation

Abstract

Introduction: Diet can affect the outcome of mechanical ventilation in patients with chronic respiratory failure.

Aim of the work: To compare the effect of a high fat, low carbohydrate enteral feeding to a standard iso-caloric enteral feeding on arterial carbon dioxide tension and ventilation time in patients with type II respiratory failure secondary to pulmonary disease requiring mechanical ventilation.

Subjects and methods: One hundred patients with type II respiratory failure secondary to pulmonary disease requiring mechanical ventilation who could be enterally fed in the respiratory intensive care unit of Ain Shams University Hospitals were enrolled in this study. They were divided randomly into:

Group A: included fifty patients who received standard iso-caloric feeding with carbohydrates (53.3%), fats (30%) and proteins (16.7%).

Group B: included fifty patients who received iso-caloric high fat low carbohydrate feeding with carbohydrates (28.1%), fats (55.2%) and proteins (16.7%) also through the Ryle tube.

Results: Group B had 16% decrease in arterial carbon dioxide tension, 8% decrease in the minute volume at weaning, and spent on average 62 h less on mechanical ventilation.

Conclusion: A nutritional regimen with a high fat content may reduce ventilatory requirements and therefore reduce the duration of mechanical ventilation.

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Introduction

The relationship between pulmonary diseases and nutrition is significant. Malnutrition and its associated adverse pulmonary effects can directly affect outcomes in the individual with pulmonary disease. The use of nutrition support is common for these patients as a supportive or therapeutic measure \cite{1}.

Recent nutrition surveys in hospitals continue to suggest that 40–50% of patients, particularly those in the intensive care unit, have a moderate degree of malnutrition \cite{2}.

Nutritional support is essential for mechanically ventilated patients to meet their energy requirements and to maintain or
even to enhance their muscle strength for facilitating ventilator weaning [3].

Carbon dioxide production may be determined in part by the composition of enteral or parenteral nutrition, which in turn may affect the weaning process [4].

Published reports of respiratory failure precipitated by high carbohydrate feeding have drawn attention to the carbohydrate and fat content of the patient’s diet. In patients with chronic or acute retention of carbon dioxide (Hypercapnia), one goal of dietary therapy is to decrease carbon dioxide production. High carbohydrate production can precipitate acute respiratory failure in patients with chronic pulmonary disease and can complicate weaning in ventilator dependent patients. Because the complete combustion of fat yields less carbon dioxide than combustion of either carbohydrate or protein, a high fat diet may be preferable for patients with pulmonary disease [5].

**Aim of the work**

The aim of this work is to compare the effect of a high fat, low carbohydrate enteral feeding to a standard isocaloric enteral feeding on arterial carbon dioxide tension and ventilation time in patients with type II respiratory failure secondary to pulmonary disease requiring mechanical ventilation.

**Subjects and methods**

This study took place in Ain Shams University Hospitals in the period from October 2006 till September 2009.

One hundred patients with type II respiratory failure secondary to pulmonary disease requiring mechanical ventilation who could be enterally fed in the respiratory intensive care unit of Ain Shams University Hospitals were enrolled in this study. The patients were randomly allocated into two groups:

- **Group A**: included fifty patients who received standard iso-caloric feeding with carbohydrates (53.3%), fats (30%) and proteins (16.7%) through Ryle tube according to W.H.O. September 1998.
- **Group B**: included fifty patients who received iso-caloric high fat low carbohydrate feeding with carbohydrates (28.1%), fats (55.2%) and proteins (16.7%) also through Ryle tube.

The diagnosis of respiratory failure type II secondary to pulmonary disease was made on clinical and radiological basis and mechanical ventilation was initiated according to American thoracic society criteria 2004 [6].

On admission data were collected as regards:
- Age,
- Residence,
- Occupation,
- Smoking history,
- History of cardiac, liver, renal, thyroid or gastrointestinal disease,
- History of alcoholism, drug addiction, malignancy or tuberculosis,
- History of the respiratory illness.

Thorough clinical examination was performed. The following investigations were done:

1. Fasting and two hours postprandial blood sugar.
2. Serum creatinine, blood urea nitrogen.
3. Serum SGOT, SGPT, total bilirubin, direct bilirubin and total proteins.
4. Prothrombin time and partial thromboplastin time.
5. Complete blood picture with a differential white blood cell count.
7. Baseline arterial blood gases.

Patients were assessed using the simplified acute physiology score (SAPS II) system [7] which includes the following fifteen items:

1. Age in years.
2. Heart rate.
3. Systolic blood pressure in mmHg.
4. Arterial oxygen tension in mmHg/fraction of inspired oxygen.
5. Urinary output.
7. Blood urea nitrogen in mg/dl.
8. White blood cell count/mm³.
9. Serum potassium in mmol/dl.
10. Serum sodium in mmol/dl.
11. Serum bicarbonate level in meq/l.
12. Serum bilirubin in mg/dl.
15. Type of admission.

All patients included in the study had SAPS II score less than 39.5 as this is the cutoff point below which patients have the same severity of illness and become more likely to survive during the period of mechanical ventilation till weaning [8].

Patients were excluded from the study if they were found to have Diabetes mellitus, Nephrotic syndrome, Hepatic failure and Malabsorption syndrome.

The study was given ethical approval by the chest department of Ain Shams University Hospitals.

**Nutrition**

The feeding regimen was only commenced after a stable ventilatory state had been achieved at which patient was hemodynamically stable and did not require change of ventilator parameters till weaning. Water was administered via a Ryle tube for 12 h before commencing the enteral feed in order to avoid gastric distention, vomiting and sepsis as patients were given muscle relaxant at the start of mechanical ventilation.

Patients were then allocated randomly into two groups to receive:

1. The standard iso-caloric feed according to W.H.O. 1998 that supplies 4300 kcal, which included the following daily aliquots per patient:
--- Eggs 50 g.
--- Meat 250 g or cooked chicken 400 g.
--- Cooked cheese 100 g.
--- Full cream milk 400 g.
--- Fruits 400 g.
--- Rice 100 g.
--- Cooked vegetables 300 g.
--- Bread 480 g.
--- Sugar 20 g.
--- Oil 20 g.
--- Halawa 50 g.
--- Jam 100 g.
--- Yoghurt 120 g.
--- Fresh vegetables 300 g.

(2) The iso-caloric high fat, low carbohydrate feed that supplies 3000 kcal, which included the following daily aliquots per patient:
--- Eggs 150 g.
--- Meat 250 g or cooked chicken 400 g.
--- Cooked cheese 120 g.
--- Full cream milk 600 g.
--- Powdered milk 80 g.
--- Fruit juice 200 g.
--- Rice 30 g.
--- Cooked vegetables 200 g.
--- Bread 50 g.
--- Sugar 5 g.
--- Butter 20 g.
--- Oil 30 g.

It was then tailored for each patient using the Harrison-Benedict equation, which predicts resting energy expenditure:

For men: resting energy expenditure = 66 + 13.7\(W\) + 5\(H\) – 6.8\(A\).

For women: resting energy expenditure = 655 + 9.6\(W\) + 1.7\(H\) – 4.7\(A\).

Where \(W\) = body weight in kg, \(H\) = height in cm and \(A\) = age in years.

And for more accurate assessment of total energy expenditure two factors were considered:
--- Activity factor: which is 1.2 for a patient confined to bed.
--- Stress factor: which is 1.5 for severe infections.

These daily rations were blended under aseptic conditions, refrigerated and divided into aliquots of 200 ml each warmed and administered through Ryle tube every 2 h with stomach rest from 12 a.m. to 6 a.m.

Any additional carbohydrate load in the form of intravenous dextrose or syrup for oral drugs was avoided. Feeding was discontinued for 30 min before and after chest physiotherapy.

**Mechanical ventilation**

The patients participating in this study were on controlled ventilation through auffed endotracheal tube with a time cycled ventilator (Drager Evita-4).

Normal clinical criteria were used to determine the initial settings of the tidal volume (6–10 ml/kg ideal body weight) and frequency of ventilation (12–20 breaths/min). An inspired oxygen concentration of between 30% and 50% was used.

Mechanical ventilation using volume controlled mode, was given thereby to maintain arterial carbon dioxide tension between 36 and 44 mmHg and arterial oxygen tension value above 90 mmHg.

Prior to ventilation blood gas measurements were made. Baseline measurements were taken at the start of intermittent positive pressure ventilation and subsequently recorded at 12 h intervals.

After enrollment in the study measurements were carried out within one hour after the start of feeding, every 12 h thereafter and immediately prior to weaning. Tidal volume, frequency of respiration, minute volume and peak inspiratory pressure were obtained from the digital display of the ventilator.

Inspired oxygen concentration was adjusted according the clinical state of the patient. It was measured using a paramagnetic oxygen analyzer which was calibrated with the following gases: 100% nitrogen, air and 100% oxygen. Arterial blood was collected in heparinized plastic syringes, the time from collection to blood gas analysis was always less than 10 min.

**Weaning**

Weaning was performed using the continuous positive airway pressure mode of the ventilator and was started as soon as the patient fulfills the following criteria:

--- Minute ventilation <12 l/min.
--- Frequency of ventilation <20/min.
--- Arterial oxygen tension at fraction of inspired oxygen 40% >90 mmHg.
--- Arterial carbon dioxide tension ranges from 35 to 55 mmHg.
--- PH more than or equal to 7.3.

Each patient was assessed daily and the weaning process implemented if the above criteria were met. Weaning was considered successful if the patient maintains these criteria for 48 h after extubation.

**Data management**

Clinical and experimental data were entered and checked using a Microsoft access database and transferred to SPSS statistical package version 10 for analysis.

Normality test for each parameter was done to determine if it followed a normal Gaussian distribution or not.

All parameters analyzed were found to have a normal distribution so mean and standard deviation were used and Chi-square test was used for analysis of non parametric data while only arterial carbon dioxide tension was found to be not normally distributed so median was used and Mann–Whitney test was used for analysis of non parametric data.

**Results**

A total of 100 patients diagnosed as having type II respiratory failure secondary to pulmonary disease indicated for mechanical ventilation were enrolled into this study, they were divided randomly into two groups A and B each consisting of 50 patients.

Those patients in group A received the standard iso-caloric feeding, while those in group B received the iso-caloric high fat low carbohydrate feeding enterally.
Enteral feeding was done through Ryle tube during the period of mechanical ventilation with few complications occurring in the form of diarrhea that stopped after giving usual anti-diarrhea medications.

All patients were observed and measurements were taken as scheduled till weaning from mechanical ventilation.

Demographics

Group A included 40 male patients and 10 female patients with mean age 52.7 years and standard deviation 13.22. Group B included 40 male patients and 10 female patients with mean age 55.38 years and standard deviation 11.86. There was no statistical significant difference ($p > 0.01$) between both groups regarding the mean age and gender (see Table 1).

Simple acute physiology score II (SAPS II)

There was no statistical significant difference ($p > 0.01$) between both groups on admission (see Table 2).

Energy requirements

There was no statistically significant difference between both groups regarding the mean energy requirements.

Mechanical ventilation outcome

Arterial carbon dioxide tension

There was no statistically significant difference between both groups regarding the arterial carbon dioxide tension at the start of feeding ($p > 0.05$) but there is a highly significant statistical difference between both groups regarding the arterial carbon dioxide tension ($p < 0.001$) at weaning (see Table 3).

There was a highly significant statistical difference between both groups regarding the average arterial carbon dioxide tension ($p < 0.001$) at weaning as in the high fat feed group arterial carbon dioxide tension decreased by about 16% while in the isocaloric standard feed arterial carbon dioxide tension increased by about 4% (see Table 4).

Minute volume

There was no statistically significant difference between both groups regarding the minute volume at the start of feeding ($p > 0.05$) but there was a highly significant statistical difference between both groups regarding the minute volume ($p < 0.001$) at weaning (see Table 5).

There was a highly significant statistical difference between both groups regarding the minute volume ($p < 0.001$) at weaning as in group B minute volume decreased by about 8% while in group A minute volume increased by about 2% (see Table 6).

Table 2 Mean energy requirements in kcal for both groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy requirements</td>
<td>A</td>
<td>2886</td>
<td>391</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2849</td>
<td>368</td>
</tr>
</tbody>
</table>

Table 3 Average arterial carbon dioxide tension ($PaCO_2$) at the start of the feeding and at weaning in both groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Median</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaCO_2 at the start of feeding</td>
<td>A</td>
<td>44.244</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>45.978</td>
</tr>
<tr>
<td>PaCO_2 at weaning</td>
<td>A</td>
<td>46.01</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>38.624</td>
</tr>
</tbody>
</table>

Tidal volume

There was no statistically significant difference between both groups regarding the tidal volume at the start of feeding ($p > 0.05$) but there was a highly significant statistical difference between both groups regarding the tidal volume ($p < 0.001$) at weaning (see Table 7).

There was a highly significant statistical difference between both groups regarding the tidal volume ($p < 0.001$) at weaning as in group B tidal volume decreased by about 4% while in group A tidal volume increased by about 7% (see Table 8).

Peak inspiratory pressure

There was a highly significant statistical difference between both groups regarding the peak inspiratory pressure at the start of feeding and at weaning ($p < 0.001$) (see Table 9).

There was a highly significant statistical difference between both groups regarding the peak inspiratory pressure ($p < 0.001$) at weaning as in group B peak inspiratory pressure decreased by about 12% while in group A peak inspiratory pressure increased by about 6% (see Table 10).

Duration of mechanical ventilation

There was a highly significant statistical difference ($p < 0.001$) between both groups as regards duration of mechanical ventilation as group B patients spent about 62 h less than those receiving the isocaloric standard feed. This is further demonstrated in Fig. 1 which shows the significant difference between group A and group B as regards duration of mechanical ventilation (see Table 11).

Discussion

A significant relationship between nutrition and pulmonary disease is well documented. Pulmonary disease, whether acute or chronic, is associated with an increased risk and incidence of malnutrition. The presence of malnutrition further impairs the pulmonary system, leading to a decline in outcomes. The use of nutrition support in those with pulmonary disease is common, especially in hospitalized patients. Enteral nutrition is frequently used unless gastrointestinal function is impaired, requiring the use of parenteral nutrition.

It has been observed in our respiratory intensive care unit that weaning patients with type II respiratory failure secondary to pulmonary disease from mechanical ventilation became an
increasingly difficult task leading to prolonged stay in I.C.U. with its complications and ventilator dependency, this raised the interest in searching for other tools to help weaning of these patients and one of these tools is nutritionally managing these patients in order to facilitate their early weaning from mechanical ventilation and minimize their hospital stay.

Ireton-jones [9] stated that providing nutrition support to prevent or treat malnutrition without exacerbating existing

<table>
<thead>
<tr>
<th>Table 4</th>
<th>The change in average arterial carbon dioxide tension (PaCO₂) at the start of the feeding and at weaning in the same group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in average PaCO₂ at the start of the feeding and at weaning in group A</td>
<td>−1.766</td>
</tr>
<tr>
<td>Change in average PaCO₂ at the start of the feeding and at weaning in group B</td>
<td>7.354</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Average minute volume at the start of the feeding and at weaning in both groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mean</td>
</tr>
<tr>
<td>Minute volume at the start of feeding</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Minute volume at weaning</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
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<table>
<thead>
<tr>
<th>Table 6</th>
<th>The change in minute volume at the start of the feeding and at weaning in the same group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in minute volume at the start of the feeding and at weaning in group A</td>
<td>−0.216</td>
</tr>
<tr>
<td>Change in minute volume at the start of the feeding and at weaning in group B</td>
<td>0.706</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 7</th>
<th>The average tidal volume at the start of the feeding and at weaning in both groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mean</td>
</tr>
<tr>
<td>Tidal volume at the start of feeding</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Tidal volume at weaning</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8</th>
<th>The change in tidal volume at the start of the feeding and at weaning in the same group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in tidal volume at the start of the feeding and at weaning in group A</td>
<td>−36.701</td>
</tr>
<tr>
<td>Change in tidal volume at the start of the feeding and at weaning in group B</td>
<td>20.84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 9</th>
<th>The average peak inspiratory pressure at the start of the feeding and at weaning in both group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mean</td>
</tr>
<tr>
<td>Peak inspiratory pressure at the start of the feeding</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Peak inspiratory pressure at weaning</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10</th>
<th>The change in peak inspiratory pressure at the start of the feeding and at weaning in the same group.</th>
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</thead>
<tbody>
<tr>
<td>Change in peak inspiratory pressure at the start of the feeding and at weaning in group A</td>
<td>−1.74</td>
</tr>
<tr>
<td>Change in peak inspiratory pressure at the start of the feeding and at weaning in group B</td>
<td>4.004</td>
</tr>
</tbody>
</table>
lung disease is a clinical challenge. Metabolism of macronutrients yields carbon dioxide (CO₂) oxidative end products with CHO producing the greatest amount. The respiratory quotient (RQ, CO₂ produced over oxygen (O₂) consumed) is a measure that reflects substrate utilization. When the value exceeds 1.0, O₂ consumption must increase, resulting in an increased work of breathing.

This is supported by the study made earlier by Delafosse et al. [10], who found that in the patient with pulmonary disease, this increased workload can further impair respiratory function, resulting in respiratory failure or the inability to wean from mechanical ventilation.

Covelli et al. [11] also reported hypercapnia and respiratory failure in patients receiving high-CHO parenteral formulations. Standard practice at that time was to provide 100% of non protein calories in the form of dextrose and provide lipid intermittently as a source of essential fatty acids. According to the detrimental effects observed with excessive dextrose intake, altering parenteral nutrition formulas to provide increased lipids and reduced dextrose amounts became standard practice.

This study was designed to investigate the effects of iso-caloric high fat, low carbohydrate enteral feeding on arterial carbon dioxide tension and weaning from mechanical ventilation in comparison to a standard iso-caloric enteral feeding.

One hundred patients with type II respiratory failure secondary to pulmonary disease requiring mechanical ventilation who could be enterally fed in the respiratory intensive care unit of Ain Shams University Hospitals were enrolled in this study.

For the sake of homogeneity of the sample we divided the patients into two groups each including the same number of males and females with the same severity of illness as indicated by the simple acute physiology score II.

Group A included fifty patients (40 males and 10 females) who received standard iso-caloric feeding with carbohydrates (53.3%), fats (30%) and proteins (16.7%) through Ryle tube according to W.H.O. September 1998.

Group B included fifty patients (40 males and 10 females) who received iso-caloric high fat low carbohydrate feeding with carbohydrates (28.1%), fats (55.2%) and proteins (16.7%) also through Ryle tube.

In this study we found that arterial carbon dioxide tension had significantly decreased from the start of feeding till weaning in the iso-caloric high fat feeding group patients by 16% and this matches another study done by Alsaady et al. [14], who found a significant decrease in PaCO₂ in the high fat feeding group by 24% also this finding is supported by two previous studies the first one done by Alsaady et al. [14], who found a significant decrease in PaCO₂ in the high fat feeding group by 16% and the second one done by Grafinkel et al. [16], which showed a significant decrease in CO₂ production (vCO₂) in the high fat feeding group by 24% and this change in CO₂ production could account for all of the differences we observed because PaCO₂ is linearly related to both alveolar ventilation and CO₂ production a 24% decrease in CO₂ production would result in the combination of the 16% fall in the PaCO₂ and 8% fall in minute ventilation we observed in our study.

In contrast Van den berg et al. [13], who used similar feeding protocols to our study found that there is no difference in arterial carbon dioxide tension in both groups between the start of the feed and at weaning but this could be attributed to different modes of mechanical ventilation used which affected the oxygen consumption of the patients VO₂ and consequently the respiratory quotient RQ which was measured in this study in addition to the fact that the number of patients who had acute on top of chronic respiratory failure was higher in this study than ours.

While in the iso-caloric standard feed group patients arterial carbon dioxide tension increased by about 1% and this agrees with the study conducted by Alsaady et al. [14], but differs from that study done by Cai et al. [12], who found a decrease in PaCO₂ by 17% in the iso-caloric standard feed group and this could be explained by the difference in the underlying diseases of the patients of this group, in our study about 25% only of the patients had chronic obstructive pulmonary disease while in the other study all the patients had chronic obstructive pulmonary disease but [13] stated that there were no differences in the PaCO₂ of this group during weaning.

Our findings therefore can be explained by considering the differences in CO₂ production resulting from the metabolism.

<table>
<thead>
<tr>
<th>Table 11 The mean duration of mechanical ventilation in hours in both groups.</th>
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</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>Duration of mechanical ventilation in hours</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
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</tbody>
</table>
of carbohydrate, fat and protein, it is well established that the combustion of one calorie of each of these nutrients produces 0.2, 0.15 and 0.19 of CO₂ respectively. The combustion of 1000 calories of the high fat feed used in this study would result in the production of 173.6 L of CO₂ this contrasts with the 186 L of CO₂ produced from 1000 calories of the standard feed.

As regards the minute volume measured at the start of the study there was no significant difference between the two feeding groups however, it was found that it decreased significantly by about 8% in the high fat feeding group at weaning while it showed a significant increase by about 2% in the standard feeding group, these findings are explained by the change seen in our study regarding tidal volume which showed a significant decrease in the high fat feed group by about 4% and a significant increase in the standard feed group by about 7% and as the minute volume represents the tidal volume multiplied by the respiratory rate it is concluded that the frequency of breathing decreased markedly at weaning in both groups and so there was a favorable breathing pattern that facilitated weaning in both groups.

But this could not be attributed to the effect of the feeding alone as improvement in pulmonary function and decreased dead space ventilation which were not measured in this study may attribute to this change also carbon dioxide production and oxygen consumption were not measured in this study which could have affected the breathing pattern and this may affirm the results found by Van den Berg et al. [13] who found no significant difference between the two feeding groups at weaning as regards both minute volume and tidal volume.

We found in our study that the high fat low carbohydrate feeding group spent on average 62 h less on mechanical ventilation. There are several factors which might have affected this finding. The amount of sedative and muscle relaxing agents may have influenced the ease with which patients were weaned from the ventilator; no significant differences in the administration of these agents to the treatment groups were, however, seen. The clinical diagnosis and underlying lung pathology could affect the duration of ventilation though both groups were on mechanical ventilation for a similar time before starting enteral nutrition. Although there were some differences in the etiology of the respiratory failure between the two groups we do not feel these were sufficient to account for the results obtained. Differences in the clinical state at initiation of feeding could have influenced the duration of ventilation. These include CO₂ production and dead space ventilation which were not measured. PaCO₂ and minute volume at the start of feeding were not different in the two groups and, if similar CO₂ productions are assumed, the physiological dead space would also be similar. If other clinical factors did not differ in the two groups, then changes in the dead space to tidal volume ratio (VD/VT) or CO₂ production could account for our findings. Other clinical parameters that could have affected the duration of mechanical ventilation were not different in the two groups during the weaning period. These included temperature, oxygen exchange, lung mechanics and amount of sedation.

So in conclusion it is obvious that the composition of diet could have affected the duration of mechanical ventilation and made the difference found between the two groups.

Maximal inspiratory pressure is one of the standard measurements employed to determine a need for the continuation of mechanical ventilation as stated by Jubran [15], global inspiratory muscle strength is assessed by measuring maximal inspiratory pressure while the patient makes a maximum inspiratory effort against an occluded airway, preceded by complete exhalation to residual volume.

In this study we found that peak inspiratory pressure differed significantly at the start of feeding in both groups and this may be attributed to the difference of underlying diseases in both groups which affects the respiratory airway resistance as well as the nutritional status of the patients which may affect the thoraco-pulmonary function of mechanically ventilated patients as mentioned by Pingleton [17], while at weaning we discovered that peak inspiratory pressure had significantly decreased in the high fat feeding group by about 12% and significantly increased in the standard feeding group by about 6% and this could be explained by many factors, first the high fat feed group contained a higher number of chronic obstructive pulmonary disease patients and this kind of disease with chronic airflow limitation decreases the peak inspiratory pressure as evidenced by the study done by Claudio et al. [18] which showed that patients with severe air flow obstruction had lower values of peak inspiratory pressures and also in patients with mild to moderate functional impairment, which was not measured in our study, there is decreased peak inspiratory pressure that could suggest earlier deterioration of inspiratory muscles in this type of patients together with the fact that the nature of the disease is associated with malnutrition and skeletal muscle wasting as mentioned by Laghi et al. [19], also the mean age in the high fat feed group was higher than the standard feed group which affects the respiratory muscle performance and strength as proved by Enright et al. [20].

Type of feed could not be the principle factor for this decrease in peak inspiratory pressure observed in the high fat feed group due to the short period of the study which could not allow the change of diet elements to take its effects on the respiratory muscles and affect the peak airway pressure and that both types of feeds contained the same amount of proteins (16.7%) which is the main source for muscle building blocks in the diet.

In conclusion, the study revealed better feeding practices that affected the outcome of patients in group B in the form of a significant decrease in arterial carbon dioxide tension, minute volume, tidal volume, peak inspiratory pressure which had an impact on a decrease of the duration of mechanical ventilation and easy weaning.

Therefore leaving patients with type II respiratory failure secondary to pulmonary disease who are admitted to ICU and indicated for mechanical ventilation to the already present feeding practices with the standard feed will further impair the ventilatory parameters of these patients and will hinder the process of weaning from mechanical ventilation. Feeding these patients with high fat low carbohydrate feed will prevent the deterioration of these parameters and accordingly will influence the weaning process and early liberation of these patients from mechanical ventilation hence favorably affecting the outcome of the ICU stay. Considerable effort should be taken to apply this type of feeding and properly nourish these patients and prevent further deterioration in their status.

More attention should be paid to the dietary composition of the nutritional support given to patients requiring artificial ventilation for acute respiratory failure. A nutritional regimen with a high fat content may reduce ventilatory requirements and therefore reduce the duration of mechanical ventilation.
This would significantly reduce morbidity and mortality related to complications of mechanical ventilation. Further studies are now required to understand the mechanisms of these effects and confirm these findings in a broader cross-section of acutely ill patients.

**Conflict of interest**

We have no conflict of interest to declare.

**References**