Diaphragmatic ultrasound as a predictor of successful extubation from mechanical ventilation in elderly patients

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ABSTRACT

Background:

Although mechanical ventilation (MV) is life-saving in a patient with acute respiratory distress which is more prevalent in the elderly age group, it is also one of the most important causes of diaphragmatic dysfunction and thus MV weaning failure. Diaphragmatic function assessment has a crucial role in the assessment of the weaning outcome. Bedside diaphragmatic ultrasound (US) has an important role in the assessment of diaphragmatic thickness and function with recently used multifunction indices such as diaphragmatic excursion and velocity. Aim: We aim to evaluate the role of ultrasonographic function indices of the diaphragm in the weaning of mechanically ventilated elderly ICU patients and study the relationship between the ultrasonographic indices, time for mechanical ventilation and weaning time.

Results:

Bedside diaphragmatic ultrasonographic examination was performed on 60 patients Aged ≥ 70 years old, who were intubated, mechanically ventilated in ICU. The percentage of patients with Diaphragmatic dysfunction (DD) compared to non-diaphragmatic dysfunction (non-DD) was 3:1. The percentage of weaning success was higher in the non-DD group than the DD group (76.9% and 28.9% respectively). Diaphragmatic function indices had statistical significance in differentiating both DD and non-DD groups. The cutoff value for diaphragmatic thickness, excursion and velocity was about (10mm&10mm, 13mm&12mm and 16&15mm/s) with area under the curve (0.891&0.771, 0.794&0.771 and 0.692&0.71) on the right and left sides respectively.

Conclusion:

Bedside diaphragmatic ultrasound including multifunction indices has an important role in detecting diaphragmatic dysfunction and thus weaning failure as well as the duration of the mechanical ventilation negatively correlated with the sonographic
indices in elderly patients intubated and mechanically ventilated more than 48 hours in ICU.

**Keywords:** Mechanical ventilation, Diaphragmatic US, function indices, Diaphragmatic dysfunction.

**Background**

Nowadays, there are an increasing percentage of elderly, critically ill patients in ICU, who need mechanical ventilation support due to several different causes e.g. acute respiratory failure, shock and coma (Flaatten et al, 2017). Mechanical ventilation is being one of the most critical factors predicting both; short and long-term outcomes (HSU et al., 2020).

Although mechanical ventilation is life-saving for patients with acute respiratory distress, it causes weaning failures in approximately 20% of patients due to rapid deterioration of diaphragm muscle endurance and strength; this condition is called ventilator-induced diaphragm dysfunction (Liu and Li, 2018).

Weaning trials are usually started only after recovery or improvement of the underlying disorders that necessitated mechanical ventilation. Also, the patient should have an adequate gas exchange, well muscular and neurological status as well as hemodynamic stability (Conti et al., 2004).

Difficult weaning from mechanical ventilation could be defined as when patients cannot be weaned from mechanical ventilation within 7 days or requiring more than three effective spontaneous breathing trials (SBT) (Boles et al., 2007). The longer the duration of mechanical ventilation, the higher rates of morbidity and mortality (Pattarin and Sasithon, 2018). So mechanical ventilation aid should be discontinued as soon as patients can breathe spontaneously (Blackwood et al., 2011).

DD is an essential cause of weaning failure. DD can occur as a consequence of infection, hypotension, hyperglycemia, hypoxia as well as mechanical ventilation (Huang et al., 2017).

Mechanical ventilation, even after a few hours, can cause DD by reducing the force of diaphragmatic contraction and hence spontaneous breathing (Hooijman et al., 2015). DD can be aggravated by disuse atrophy of both fast and slow twitch myofibers of the diaphragm after administration of neuromuscular blocking agents (Theerawit et al., 2018).

Difficult weaning is when patients cannot wean from mechanical ventilation within 7 days or require up to three spontaneous breathing trials (SBT) [3]; the prevalence of difficult weaning is about 20% in patients requiring mechanical ventilation [4]. Patients who require mechanical ventilation for longer durations have higher rates of mortality [4] and morbidity, including ventilator-associated pneumonia [5]; consequently, mechanical ventilation should be discontinued as soon as patients are capable of breathing [6].
Diaphragmatic activity and function during mechanical ventilation could be assessed by several monitoring tools such as electromyography, pressure-derived parameters, and ultrasound (Schepens et al., 2020).

Recently bedside ultrasound has a major role in the main aspects of critical illness management at ICU. It is a simple, accurate, reliable, non-invasive, cheap and non-hazardous tool for the assessment of many organs and structures (Turton et al., 2019). Various sonographic indices, such as diaphragmatic excursions and changes in diaphragm thickness during inspiration are used for assessing DD in varies study (Boussuges et al., 2020) (Boussuges et al., 2019).

To our knowledge, few studies discussed the important role of diaphragmatic ultrasound in an elderly patient (Huang et al., 2017) and concerned with study the relation between the diaphragmatic ultrasound indices and mechanical ventilation which are the main issues we concerned with and discussed in this article.

2. Methods:

2.1. Patients:

After approval of the ethical committee in the Faculty of Medicine, number FWA000017585, this prospective study was conducted over 60 patients from January 2019 till January 2021. Written informed consent was obtained from patients’ legal guardian(s) after explaining of the procedure to participate in this research.

Patients were included when they met all of the following criteria:

- Aged ≥ 70 years old.
- Both males and Females are included.
- Mechanically ventilated for more than 48 hours.
- Suitable for a SBT included: the patients’ respiratory rate ranging from 10-35 breaths/min, PaO2/FiO2 ratio was ≥200, with positive end-expiratory pressure (PEEP) ≤ 5 cm H2o, FiO2< 50% and hemodynamically stable (ie, heart rate < 120 beats/min; systolic blood pressure, 90–160 mm Hg; and minimum or no vasopressor use, such as noradrenaline <0.05 μg/kg/min or dopamine or dobutamine<5 μg/kg/min).

The proper exclusion criteria were:

- Patients who were unable to sit in the semi-recumbent position or chest wall was unable to be accessed.
- Tracheostomized patients.
- Patients with neuromuscular diseases, Diaphragmatic paralysis, cervical injury, Pneumothorax or mediastinalemphysema.

For all patients, the following were done;
1- Full history taking including: medical and surgical history.

2- Complete physical examination.

3- Admission severity assessment by using Acute Physiology and Chronic Health Evaluation II (APACHE II) score (Knaus et al., 1985).

Assessment of the included patients and the decision of patients’ extubation were done by ICU physician who was blinded to the ultrasonographic measurements.

2.2. Spontaneous breathing trial:

• Included patients were put on pressure support mode with pressure support of 7 cm H2O and PEEP of 5 cm H2O for 30 min, and then all liberation parameters were again assessed.

• A rapid shallow breathing index (RSBI) was calculated at the bedside before the spontaneous breathing trial. RSBI = respiratory rate (breaths/min)/Tidal volume (L).

2.3. The Examination protocol included:

• Diaphragmatic ultrasound was done by a trained expert with experience of about three years in the chest and diaphragmatic ultrasonography during the first 30 minutes of SBT using Mindray model M7 ultrasound machine with a 7.5–10 MHz linear and 3–5 curvilinear probes (Mindray Bio-Medical, Shenzhen, China).

• Patients were positioned in the semi-recumbent position with assessing each hemidiaphragm.

• **Diaphragmatic thickness:** putting the transducer on the subcostal margin at the midclavicular line, the US beam was directed cranially to detect the best image for measuring the end expiratory diaphragmatic thickness using B-mode.

• **Diaphragmatic excursion:** was recorded as an upward motion of the M-mode tracing. The amplitude of excursion was measured on the vertical axis of the tracing from the baseline to the point of a maximum height of inspiration.

• **Diaphragmatic velocity:** was calculated as diaphragmatic movement (mm) divided by the duration of diaphragmatic contraction.

2.4. Outcomes

• When the patient was able to maintain breath for 48 h without ventilator support, it was considered as Successful weaning.

• Needing mechanical ventilation within 48 h of self-breathing was considered as Primary weaning failure.

• Requiring mechanical ventilation after 48 h of taking self breath, was considered as Secondary weaning failure a successful weaning, i.e., respiratory failure occurring past the 48 h of self-breathing.
2.5. Statistical analysis:

Data were analyzed using the Statistical Package for Social Science (SPSS) version 22.0. Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were used:

- Independent-samples t-test of significance was used when comparing two means.
- Chi-square (X²) test of significance was used to compare proportions between two qualitative parameters.
- Mann Whitney U test: for two-group comparisons in non-parametric data.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:
  - P-value <0.05 was considered significant.
  - P-value <0.001 was considered as highly significant.
  - P-value >0.05 was considered non-significant.

3. Results:

- Among 60 patients included in this study, 45 of them had DD and 15 patient had non-DD (Figure 1). Both DD and non-DD Groups were comparable in demographic data (in terms of age, sex and BMI cause of admission) and there was no statistically significant difference between groups (p-value > 0.05 NS) (Table 1).

- There was no statistical significant difference in APACHE Score of the patients with both DD and non-DD with p-value > 0.05 (table 1).

![Flow chart of patients’ distribution](https://www.turkjphysiotherrehabil.org)
Table (1): Comparison between the two studied groups according to demographic data

<table>
<thead>
<tr>
<th></th>
<th>DD group (N=45)</th>
<th>Non DD group (N=15)</th>
<th>T*/ X^2**/ Z^</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>79.9 ± 5.9</td>
<td>79.4 ± 6.71</td>
<td>0.65*</td>
<td>0.518</td>
</tr>
<tr>
<td>BMI</td>
<td>25.7 ± 2.23</td>
<td>25.25 ± 1.97</td>
<td>0.7*</td>
<td>0.49</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>25/20 (55.6%)</td>
<td>8/7 (53.3%)</td>
<td>0.022**</td>
<td>0.88</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARDS</td>
<td>19(42.2%)</td>
<td>8 (53.3)</td>
<td>0.202**</td>
<td>0.653</td>
</tr>
<tr>
<td>COPD</td>
<td>18(40%)</td>
<td>8 (53.3)</td>
<td>0.36**</td>
<td>0.55</td>
</tr>
<tr>
<td>HTN</td>
<td>24(53.3%)</td>
<td>9(60%)</td>
<td>0.02**</td>
<td>0.88</td>
</tr>
<tr>
<td>DM</td>
<td>17(37.8%)</td>
<td>6(40%)</td>
<td>0.02**</td>
<td>0.88</td>
</tr>
<tr>
<td>Cardiac</td>
<td>19(42.2%)</td>
<td>7(46.7%)</td>
<td>0.00**</td>
<td>1</td>
</tr>
<tr>
<td>APACHE Score</td>
<td>17 (15-19)</td>
<td>19(15-20)</td>
<td>1.44^</td>
<td>0.149</td>
</tr>
</tbody>
</table>

Data expressed as mean ± SD, proportion, median (IQR)

*T = student t test

**X^2 = Chi square test

^ Z=Mann-Whitney

Both groups were also comparable in ventilation data (in terms of ABG, hypoxic index and RSBI). Both groups were also comparable in hemodynamic data (in terms of mean arterial blood pressure (NIBP) before extubation and Heart rate (HR) before extubation and there were no statistically significant difference between groups (p-value > 0.05 NS) (Table 2).
Table (2): Comparison between the two studies groups according to ventilation and hemodynamic data.

<table>
<thead>
<tr>
<th></th>
<th>DD group (N=45)</th>
<th>Non DD group (N=15)</th>
<th>T*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxic index</td>
<td>263.44 ± 20.73</td>
<td>261.73 ± 17.1</td>
<td>0.317</td>
<td>0.753</td>
</tr>
<tr>
<td>RSBI</td>
<td>99.8 ± 5.43</td>
<td>100.93 ± 6.54</td>
<td>0.58</td>
<td>0.57</td>
</tr>
<tr>
<td>ABG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>7.36± 0.04</td>
<td>7.38± 0.039</td>
<td>1.16</td>
<td>0.256</td>
</tr>
<tr>
<td>PaO2</td>
<td>93.8 ± 4.56</td>
<td>93.47 ± 4.32</td>
<td>0.272</td>
<td>0.788</td>
</tr>
<tr>
<td>PaCO2</td>
<td>39.67 ± 3.62</td>
<td>41.27 ±2.89</td>
<td>1.74</td>
<td>0.093</td>
</tr>
<tr>
<td>Mean NIBP (mmHg)</td>
<td>77.56 ± 8.88</td>
<td>74.33 ±8.23</td>
<td>1.29</td>
<td>0.21</td>
</tr>
<tr>
<td>HR (B/min)</td>
<td>98.67 ± 11.08</td>
<td>98.07 ± 7.17</td>
<td>0.24</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Data expressed as mean ± SD

*T = student t test

There were highly statistically significant difference between the two as regards the duration of mechanical ventilation, duration of weaning time and the ICU length of stay there were and (p-value < 0.001) (table 3).

Table (3): Comparison between the two studied groups according to mechanical ventilation and the ICU length of stay:

<table>
<thead>
<tr>
<th></th>
<th>DD group (N=45)</th>
<th>Non DD group (N=15)</th>
<th>T*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of MV (hours)</td>
<td>493.91 ± 7.17</td>
<td>260.4 ± 38.49</td>
<td>15.999</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Duration of weaning (hours)</td>
<td>334.78 ±90.87</td>
<td>151.4 ±30.04</td>
<td>11.75</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ICU LOS (days)</td>
<td>22.3 ± 2.65</td>
<td>13.5 ±2.72</td>
<td>11.099</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Data expressed as mean ± SD

*T = student t test

Regarding the ultrasonographic finding of diaphragm: groups were comparable in ultrasound finding of the diaphragm (right and left thickness, excursion and velocity) and there were highly statistically significant difference between groups (p-value < 0.001) (table 4).

Table (4): Comparison between the two studied groups according to ultrasound finding of the diaphragm

<table>
<thead>
<tr>
<th></th>
<th>DD group (N=45)</th>
<th>Non DD group (N=15)</th>
<th>T*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt thickness (mm)</td>
<td>0.976 ± 0.078</td>
<td>1.1 ± 0.085</td>
<td>5.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lt thickness (mm)</td>
<td>0.967 ± 0.67</td>
<td>1.14 ± 0.074</td>
<td>8.06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rt excursion (mm)</td>
<td>9.87 ± 3.12</td>
<td>15.2 ± 2.43</td>
<td>6.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lt excursion (mm)</td>
<td>9.84 ± 3.58</td>
<td>16.0 ± 2.27</td>
<td>7.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rt velocity (mm/s)</td>
<td>16.09 ± 4.08</td>
<td>24.93 ± 3.71</td>
<td>7.79</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lt velocity (mm/s)</td>
<td>14.67 ± 4.34</td>
<td>25.67 ± 4.13</td>
<td>8.81</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Data expressed as mean ± SD

*T = student t test

There was a significant relation between Ultrasound finding of the diaphragm and failure of weaning as the study showed 37 patients failed to wean from mechanical ventilation (61.67%) with a Receiver Operating Characteristic (Roc) analysis for right and left thickness, excursion and velocity (figure 2) that showed an area under the curve (AUC) 0.891, 0.771, 0.794, 0.771, 0.692, 0.71 respectively (Table 5).

Table (5): ROC ultrasound finding of the diaphragm

<table>
<thead>
<tr>
<th></th>
<th>Best cut of value</th>
<th>Sensitivity</th>
<th>specificity</th>
<th>AUC</th>
<th>Z*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt thickness (mm)</td>
<td>≤ 1</td>
<td>97.3</td>
<td>78.26</td>
<td>0.891</td>
<td>8.051</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lt thickness (mm)</td>
<td>≤ 1</td>
<td>86.49</td>
<td>56.52</td>
<td>0.771</td>
<td>4.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rt excursion (mm)</td>
<td>≤ 13</td>
<td>86.49</td>
<td>56.52</td>
<td>0.794</td>
<td>5.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lt excursion (mm)</td>
<td>≤ 12</td>
<td>75.68</td>
<td>96.57</td>
<td>0.771</td>
<td>4.33</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rt velocity (mm/s)</td>
<td>≤ 16</td>
<td>67.57</td>
<td>73.91</td>
<td>0.692</td>
<td>2.52</td>
<td>0.012</td>
</tr>
<tr>
<td>Lt velocity (mm/s)</td>
<td>≤ 15</td>
<td>67.57</td>
<td>73.91</td>
<td>0.71</td>
<td>3.01</td>
<td>0.003</td>
</tr>
</tbody>
</table>
AUC= area under curve

Z=Mann-Whitney
Both groups were also comparable in weaning process success and there was a statistically significant difference between groups (p-value < 0.021) (table 6).

Table (6): Comparison between the two studied groups according to weaning process success

<table>
<thead>
<tr>
<th></th>
<th>DD group (N=45)</th>
<th>Non DD group (N=15)</th>
<th>(X^2)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaned</td>
<td>13 (28.9%)</td>
<td>10 (66.7%)</td>
<td>5.288</td>
<td>0.021</td>
</tr>
<tr>
<td>Failed weaning</td>
<td>32 (71.1%)</td>
<td>5 (33.3%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data expressed as proportion

\(X^2 = \text{Chi square test}\)

There is a moderate negative correlation between duration of mechanical ventilation and (diaphragmatic thickness, excretion and right velocity) while a strong negative correlation with left velocity.

There is a moderate negative correlation between duration of weaning and (diaphragmatic velocity, thickness and excretion) (Table 7).

Table (7): Pearson correlation for Ultrasound finding of the diaphragm and mechanical ventilation

<table>
<thead>
<tr>
<th>Duration of MV</th>
<th>Correlation coefficient(r)</th>
<th>Rt thickness</th>
<th>Lt thickness</th>
<th>Rt velocity</th>
<th>Lt Velocity</th>
<th>Rt excursion</th>
<th>Lt excursion</th>
</tr>
</thead>
<tbody>
<tr>
<td>P value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Duration of</td>
<td>Correlation co</td>
<td>-0.41</td>
<td>-0.599</td>
<td>-0.588</td>
<td>-0.639</td>
<td>-0.426</td>
<td>-0.459</td>
</tr>
</tbody>
</table>
4. Discussion

Evaluation of the diaphragm function is crucial in patients subjected to weaning from MV (McCool and Tzlepis, 2012). Ultrasonography has emerged to evaluate diaphragm function and predict weaning outcome from MV (Abdelhafeez et al., 2019).

This study included 60 patients; the percentage of included mechanically ventilated patients with DD was more than patients with non-DD (75% and 25% respectively). Only 38.3% of the included patients were successfully weaned from mechanical ventilation. The DD group showed a lower incidence of weaning

This was in agreement with the study done by Huang and colleges in 2017 which included 40 elderly patients with 30 patients with DD and only 12/40 patients (30%) had successful weaning.

A study done by Abdelhafeez and college in 2019, included 240 patients with age ranging from 20-75, 48.75% were successfully weaned and 51.25% had failed to wean. The percentage of the weaning success was higher than that of our study as this may attribute to the younger age of patients and better prognosis of patients included in their study.

In this study, the mean age of patients was no statistically significant difference in both groups (70.67 ± 6.48 and 69.4 ± 6.71) in DD and non-DD groups respectively with p-value > 0.05. The sex of patients also was statistically non-significant with the percentage of males slighter higher than females in both DD and non-DD (55.6% and 53.3% respectively).

Regarding BMI, and co-morbidities including ARDS, COPD, HTN, DM and cardiac diseases, there was no statistical significance between both DD and non-DD groups with p-value > 0.05 with the percentage of patients with the mean of BMI was nearly equal in both groups yet the percentage of patients with co-morbidities in each group was higher in patients with non-DD and this may attribute to a small sample size of the patient with non-DD. There was also non statistically significantly different in APACHE Score of the patients with both DD and non-DD with p-value > 0.05.

Theerawit and college in the study included 62 patients; agreed with us regarding the non-significance of demographic factors and APACHE II score in the detection of weaning outcome with high P value.

Yet Abdelhafeez and college stated that the APACHE II score was statistically significant in the prediction of weaning success as it increased in the failed group indicating more severity in the failed group, this may be attributed to increased the severity of cases included in our study especially with non-DD group compared to their study as mentioned before weaning success was higher in their study.

In this study the mechanical ventilation (in terms of duration of mechanical ventilation and duration of weaning time and there was a highly statistically
significant difference between both groups with a p-value < 0.001. The duration of mechanical ventilation was longer in patients with DD than the non-DD group with mean hours 493.91 ± 7.17 and 260.4 ± 38.49 respectively. Also, the duration of weaning time was longer in patients with DD than the non-DD group with mean hours 334.78 ± 90.87 and 151.4 ± 30.04 respectively.

ICU length of stay was longer in a patient with DD than in a patient with non-DD with average days 22.3 ± 2.65 and 13.5 ±2.72 respectively and this difference was highly statistically significant with a p-value < 0.001.

Abdelhafeez and the college disagreed with us regarding the significance of duration of mechanical ventilation and duration of weaning time (p values= 0.756 and 0.593) yet agreed with us regarding the significance of ICU stay duration on diaphragmatic function and weaning outcome with p values= 0.001.

In this study, the diaphragm showed increased end expiratory thickness in a patient with non-DD rather than in DD groups on both right and left sides with mean thickness 1.1 ± 0.085 mm versus 0.976 ± 0.078mm on the right and 1.14 ± 0.074 versus 0.967 ± 0.67 mm on the left. This was highly statistically significant with a p-value < 0.001. The cutoff value for diaphragmatic thickness was 10mm at both sides of the diaphragm with a sensitivity of 97.3% & 86.49% and specificity of 78.26% & 56.52% that showed an area under the curve of 0.891 and 0.771 at the right diaphragm and left diaphragm respectively.

Thimmaiah et al. at 2016 found that during quiet breathing, the normal diaphragmatic thickness estimated from the study of 200 healthy volunteers at 1.9 ± 0.5 mm (from 1.2 mm to 2.79 mm) at end expiration

Theerawit and colleges also stated that their diaphragmatic thickness was statistically significant in differentiating both DD and non-DD groups with a p-value <0.05. The mean thickness was 1.08 ± 0.47 mm for the non-DD group and 0.75 ± 0.50 mm for the DD group

The cutoff value for mean diaphragmatic thickness was >2 mm in predicting successful weaning in a study done by Ali and colleges with a sensitivity of 79.3%, and specificity of 77.7%.

In this study, the diaphragmatic excursion was also lower in patients with DD compared to the non-DD group on both right and left sides these differences were highly statistically significant with a p-value < 0.001. The mean excursion was 9.87 ± 3.12 mm compared to 15.2 ± 2.43mm on the right diaphragm and was 9.84 ± 3.58 mm versus 16.0 ± 2.27mm on the left diaphragm in both DD and non-DD patients respectively. The cutoff value for the diaphragmatic excursion was 13mm on right and 12 mm on left with a sensitivity of 86.49% & 75.68% and specificity of 56.52% & 96.57% that showed an area under the curve of 0.794 and 0.771 at the right diaphragm and left diaphragm respectively.

Osman and colleges at 2017 found that all patients with diaphragmatic excursion above value 22 mm showed successful weaning while all patients below 11 mm showed failed weaning with 10 mm was the cut off value with 83.3% sensitivity and 100% specificity and the AUC was 0.833.
Hayat and colleges in 2017 found that the cut-off value of excursion 12 mm. At an excursion of less than 12 mm, 51.5% of cases had successful weaning while

In this study, diaphragmatic velocity was also lower in patients with DD compared to the non-DD group on both right and left sides these differences were highly statistically significant with a p-value < 0.001. The mean velocities were 16.09 ± 4.08 mm/s compared to 24.93 ± 3.71 mm/s on the right diaphragm and 14.67 ± 4.34 mm/s versus 25.67 ± 4.13 mm/s on the left diaphragm in both DD and non-DD patients respectively. The cutoff value for diaphragmatic velocity below which DD is considered was 16 mm/s on the right and 15 on the left with a sensitivity of 67.57% and specificity of 73.91% bilaterally that showed area under the curve of 0.692 and 0.71 at the right diaphragm and left diaphragm respectively.

Haung and colleges found that left diaphragmatic velocity of contraction (mm/s) was significantly lower among patients of the DD group, as compared with the non-DD group. Mean diaphragmatic movements were 10.67±5.9 mm in the right and 9.32±3.54 mm in the left diaphragm of the DD group, compared with 11.99±1.75 and 16.62±4.96 mm in the non-DD group, respectively. The mean left diaphragmatic velocity of contraction was 10.94±6.67 mm in the DD group compared with 22.39±4.58 in the non-DD group, with no significant differences in the right sides. The best cut off value was >21.32 with a sensitivity of 66.67% and specificity of 92.86%.

In this study, the success of the weaning process was a statistically significant difference between both groups with a p-value = 0.021. 28.9% of patients with DD were successively weaned and 66.7% of patients with non-DD were successively weaned.

The higher percentage of weaning outcome also described in a study done by Ali and colleges with 78.8% of patient with non-DD had successful weaning versus only 7.4% of patient with DD.

In this study, there was a moderate negative correlation between duration of mechanical ventilation and (diaphragmatic thickness, excretion and right velocity) while a strong negative correlation with left velocity.

There was a moderate negative correlation between duration of weaning and (diaphragmatic velocity, thickness and excretion).

**Limitations: our study has some limitations such as:**

I. Diaphragmatic excursion depends on the maximal voluntary inspiratory effort of patients being influenced by the position of the subject, being greater in the supine position than in the setting for the same inspiratory volume, so we choose the semi-recumbent position.

II. Small sample size due to small size of our population, talking place in a single center.

III. Current reference values have been established from studies that include small or moderate number of volunteers which limit global generalization. A future
comparative study comparing and evaluating the role of both diaphragmatic ultrasonography using recent techniques as 3D elastography and other modality such as fluoroscopy for the assessment of diaphragmatic function indices and their role in extubation of mechanically ventilated ICU patients is recommended.

5. Conclusion

Bedside diaphragmatic ultrasound including multifunction indices has an important role in detecting diaphragmatic dysfunction and thus weaning failure as well as the duration of the mechanical ventilation in elderly ICU patients which negatively correlated with the sonographic indices.

6. List of abbreviations:


REFERENCES


http://dx.doi.org/10.1097/00003246-198510000-00009.


Figure titles/legends:
Figure (1): Flow chart of patients’ distribution.
Figure (2): Roc analysis for US finding of diaphragm data

Tables titles and legends:
Table (1): Comparison between the two studied groups according to demographic data
Table (2): Comparison between the two studies groups according to ventilation and hemodynamic data
Table (3): Comparison between the two studied groups according to mechanical ventilation and the ICU length of stay
Table (4): Comparison between the two studied groups according to ultrasound finding of the diaphragm
Table (5): ROC ultrasound finding of the diaphragm
Table (6): Comparison between the two studied groups according to weaning process success
Table (7): Pearson correlation for Ultrasound finding of the diaphragm and mechanical ventilation.