

Bedside Ultrasonography in Assessment of Diaphragm Function as A Predictor of Success of Weaning in Mechanically Ventilated Patients

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Abstract

Background: In mechanically ventilated patients weaning is always a problem. The aim of this study was to assess the diaphragmatic function using ultrasound by measuring diaphragmatic thickness and excursion as a predictor of the extubation outcome. **Materials And Methods:** In this study sixty-two mechanically ventilated patients from the intensive care unit were included. Those who successfully passed the spontaneous breathing trial (SBT) were enrolled. The ultrasound of the diaphragm was performed during an SBT to assess diaphragmatic function by measuring diaphragmatic excursion and thickness and further they were classified into the successful extubation group and the failed extubation group. **Results:** There was a significant increase in the successful extubation group in the diaphragmatic excursion and thickness fraction statistically. There was a statistically significant negative correlation between the duration of the mechanical ventilation and the diaphragmatic function. There is always a negative correlation between diaphragmatic function and the Acute Physiology and Chronic Health Evaluation II **Discussion:** The diaphragm is the main muscle of respiration because it contributes approximately to 70% of the TV during inspiration in normal people. Therefore, diaphragmatic dysfunction is the most important factors accounting for difficult weaning. Ultrasound is a readily available, easy to use, and noninvasive imaging modality that is commonly used for procedures and clinical evaluation in the modern ICU. Ultrasound measurements have been used for evaluation of diaphragmatic contractility either by assessment of DE or DT. In the current study, we showed that measurements of DE and DTF by ultrasound could be used to predict successful weaning. **Conclusion:** We concluded that diaphragmatic ultrasonography a noninvasive technique is a promising tool in Predicting successful extubation in mechanically ventilated patients.

Keywords: Mechanical ventilation weaning, Diaphragmatic Excursion; Diaphragmatic Thickness Fraction; Failed Extubation; Successful Extubation; Transthoracic Ultrasound

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Introduction

Weaning failure is associated with prolonged mechanical ventilation and ICU stay Risk of prolonged ventilation and premature extubation equally dangerous. Risk of prolonged mechanical ventilation such as Barotrauma, VAP and ventilator associated diaphragmatic atrophy. Premature extubation from mechanical ventilator also associated with increased mortality. To prevent this USG guided diaphragmatic function is assessed by measuring diaphragmatic thickness fraction and diaphragmatic excursion.

Aim and Objectives:

The aim of the study is to determine if measurement of diaphragmatic function by ultrasound can be used to predict successful extubation.

Materials and Methodology

STUDY DESIGN: Prospective study

STUDY PLACE: Govt Rajaji hospital, Madurai medical college.

DURATION OF STUDY: 6 MONTHS

SAMPLE SIZE: Total 62 patients were enrolled

Inclusion criteria:

Patients who were mechanically ventilated invasively for more than 48 hours and fulfilled the criteria of weaning (hemodynamic stability, RR<35/min, Hb>7g/dl and succeeded the spontaneous breathing trial (SBT))

Exclusion Criteria:

1. Patients with diaphragmatic paralysis proven by transthoracic ultrasound

2. Those with neuromuscular diseases such as muscular dystrophy, poliomyelitis and myasthenia Gravis

Patients were ventilated using volume-controlled ventilation (tidal volume [TV]=6 mL/kg).

Assessment of lung mechanics while the patients were on mechanical ventilation was performed by recording the tidal volume, RR, RSBI, static compliance (Cstat), and dynamic compliance (Cdyn) Diaphragm was visualized by ultrasound during an SBT.

All transthoracic ultrasound evaluations were performed with the patients in a semi-sitting position exposing the chest and abdomen

DIAPHRAGMATIC EXCURSION

A curvilinear transducer using the low-frequency of 3.5 MHz was placed on the right sub-costal angle between the midclavicular line and anterior axillary line during quiet breathing

M-mode imaging, the normally functioning diaphragm is represented as an echogenic line that moves freely during inspiration and expiration. Inspiration is identified on the sonographic tracing as upward flexion In the M-mode images, the distances between the probe and copula during inspiration and resting expiration were measured, and the difference between the two distances equaled the DE range

DIAPHRAGMATIC THICKNESS FRACTION

High-frequency linear probe (7–12 MHz) was used to measure the diaphragm thickness (DT)

The probe was placed at the anterior axillary line in the longitudinal plane between the seventh and ninth intercostal spaces to measure the DT. The liver window was used to visualize the diaphragm. On B-mode imaging, the diaphragm appears as a thick echogenic linear structure between highly reflective pleural and peritoneal membranes. Thickness was measured by placing calipers on reflective lines at the end of inspiration and expiration The diaphragmatic thickness fraction was calculated using this formula

$$DTF = [(Insp\ DT - Exp\ DT) / Exp\ DT] \times 100$$

Patients were extubated those who tolerate the SBT for 2 hours without exhibiting clinical signs of respiratory fatigue

successful extubation was defined as spontaneous breathing for >48 hours following extubation. A failed extubation was defined as someone who was reintubated within 48 hours.

The patients were divided into two groups according to their extubation outcome: successfully extubated group and failed extubation group

Table 1

Variable	Successful Extubation	Failed Extubation	P Value
Age	65(55-70)	60.5(52.25-70)	0.547
Duration of Mechanical ventilation	4(3-5)	8(6-10)	<0.001
Respiratory rate	18.5(15.23-25)	20(15-24)	0.575
Tidal volume(ml)	421.71+/-105.71	380.07+79.11	0.056
RSBI	43.35(34.73-53.68)	49(40.4-73.03)	0.176
Dynamic compliance	19.9(14.25-26)	13.7(11.5-18.03)	0.004
Static compliance	35.65(19.78-47.7)	23.3(16.18-32.2)	0.020
Apache II score	9.3(7.6-12.9)	15.75(11.3-24.75)	<0.001

Results

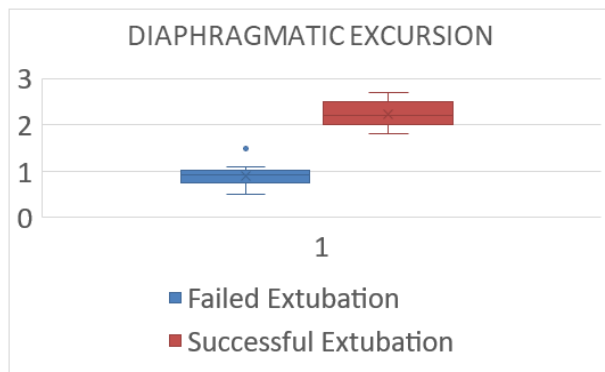
1. The two groups did not show significant difference in age but differed in APACHE II score, which was significantly lower in the successful extubation group

2. The duration of mechanical ventilation was significantly higher in the failed extubation group versus the successful extubation group

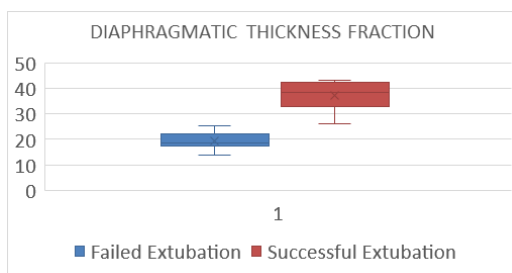
3. The diaphragmatic excursion was higher in successful extubation (2.25 cm) group than failed extubation group

Table 2: Diaphragmatic Excursion

Successful Extubation (cm)	Failed Extubation (cm)	P value
2.25(2-2.5)	0.92(0.63-1.04)	<0.001

**Figure 1**

4. The diaphragmatic thickness fraction was higher in successful extubation group than failed extubation group

**Figure 2**

5. Cstat and Cdyn and the diaphragmatic function indices represented by DE, and DTF were significantly higher in the patients who succeeded in the trial of extubation

6. Diaphragmatic thickness fraction positively correlated with dynamic compliance, negatively correlated with duration of mechanical ventilation

7. Diaphragmatic excursion was positively correlated with dynamic compliance and negatively corrected with APACHEII score

Discussion

The diaphragm is considered to be the main muscle of respiration because it contributes approximately to 70% of the TV during inspiration in normal people. Therefore, diaphragmatic dysfunction is one of the most important factors accounting for difficult weaning. Ultrasound is a readily available, easy to use, and noninvasive imaging modality that is commonly used for procedures and clinical evaluation in the modern ICU. Recently, ultrasound measurements have been used for evaluation of diaphragmatic contractility either by assessment of DE or DT. In this study, we showed that measurements of DE and DTF by ultrasound could be used to predict successful weaning. The contribution of DE and DTF in prediction of weaning outcome and compared the two parameters with each other, DTF was concluded to be superior over DE in prediction of weaning outcome, although in our study we found that DE showed superior sensitivity and specificity to DTF

Conclusion

We concluded that diaphragmatic ultrasonography a noninvasive technique is a promising tool in Predicting successful extubation in mechanically ventilated patients

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