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Original Article

Diaphragm Thickening Fraction Measurement in Successful Weaning from Mechanical Ventilation

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ABSTRACT

Background: *Among the most common problems in modern intensive care units is having trouble getting off of artificial ventilation. The diaphragm is a key muscle for breathing, and problems with it may be very common in people who need motorized ventilation. Long-term mechanical breathing and inability to wean are linked to diaphragm dysfunction.* ***Objectives:*** *The goal of this research was to establish whether or not a higher diaphragm thickening fraction is a reliable indicator of a smooth transition away from mechanical ventilation.* ***Methods:*** *This observational study was performed among 89 critically ill patients on mechanical ventilation for 48 hours who planned for weaning in the ICU at the Department of Anaesthesia, Analgesia, Palliative and Intensive Care Medicine, Dhaka Medical College Hospital, in Dhaka. The patients were all critically sick and had been on mechanical ventilation for at least 48 hours.* ***Results:*** *DTF >30% was discovered in 38 (95.0%) patients in the successful weaning group, while DTF 30% was detected in 46 (93.8%) patients in the failed weaning group, according to ultrasound findings of the diaphragm. Predicting weaning success with a DTF>30% had a sensitivity of 95.0% and a specificity of 93.8%. Likewise, its positive*

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predictive value was 92.6% and its negative predictive value was 95.8%. Furthermore, the percentage of accuracy was 94.3%. ***Conclusion:*** *The results of the current experiment showed that DTF was an efficient measure for successfully weaning patients off of mechanical breathing.*

Keywords**:** *Diaphragm, Fraction Measurement, Mechanical Ventilation.*

INTRODUCTION

The process of weaning off of mechanical ventilation is referred to as "weaning." Weaning patients off of mechanical breathing takes up forty percent of the whole time they are on it [1]. Failure to wean is a major barrier for patients who are critically unwell [2]. Complications include VILI, VAP, and vidi dysfunction (dysfunction of the diaphragm caused by ventilation) might arise if weaning is delayed. In contrast, a failure extubation can result in issues such aspiration, fatigued respiratory muscles, and poor gas exchange [1].

Assessing the patient's capacity for spontaneous breathing is the first step in developing a weaning strategy. To perform spontaneous breathing trials (SBT), clinicians employ three main techniques: trial A, where only supplemental oxygen is delivered through a T-piece connected to an endotracheal tube; trial B, where the level of CPAP used is equal to the level of PEEP; and trial C, where invasive ventilation is performed with a support for a low level of pressure (5-8 cm H2O) or automatic tube adaptation.

Weaning procedures are not initiated until the underlying sickness process that necessitated the need of mechanical breathing has either improved or been resolved. In order to determine whether weaning will be successful, a number of weaning predictors are used. Important measurements include the maximum inspiratory pressure, which is also referred to as MIP, the rapid shallow breathing index, which is also referred to as RSBI (the ratio of respiratory frequency to tidal volume), and the tracheal airway occlusion pressure of 0.1 seconds, which is also referred to as P 0.1. All three of these measurements represent the ratio of respiratory frequency to tidal volume [3,4], and CROP index (dynamic compliance, respiratory rate, oxygenation, maximum inspiratory pressure index) are all examples of such parameters [5]. Lower values are not helpful in predicting successful liberation, whereas VE levels > 15-20 L/min are useful in identifying patients who are unlikely to be released off mechanical ventilation [3].

Early weaning and shifting helped lighten the strains and pressures that patients were carrying. To tackle these issues, a reliable and accurate weaning predictor is necessary. Patients who have difficulty weaning are those who cannot stop using mechanical breathing within seven days or who need up to three SBT. 20% of patients who need mechanical breathing have difficulty weaning [6]. While receiving mechanical ventilatory support, it gets increasingly worse [7]. Techniques for evaluating the diaphragm's function, methods like The trans-diaphragmatic pressure monitoring and the dynamic magnetic resonance imaging of the diaphragm that are both included have certain limitations, such as the requirement for patient transportation, the exposure to ionizing radiation, the absence of

availability, and the invasiveness of the procedures.

Unlike such techniques, ultrasonography is risk-free, non-lethal, easily accessible, and requiring no surgery. Ultrasonography of the diaphragm, also known as diaphragm ultrasonography (DUS), is a well-known point of care method that may evaluate the size and functions of the diaphragm. The Diaphragmatic thickening fraction (DTF) is a more thorough measurement than other variables [8]. It may help with weaning success [2]. The conclusion of this study's findings may influence how intensivists manage patients and how quickly they can wean them off artificial ventilation.

OBJECTIVE

The goal of this research was to establish whether or not a higher diaphragm thickening fraction is a reliable indicator of a smooth transition away from mechanical ventilation.

METHODS & MATERIALS

This observational study was performed among 89 critically ill patients on mechanical ventilation for 48 hours who planned for weaning in the ICU at the Department of Anaesthesia, Analgesia, Palliative and Intensive Care Medicine, Dhaka Medical College Hospital, in Dhaka. The patients were all critically sick and had been on mechanical ventilation for at least 48 hours. Purposive sampling technique was followed in this study.

Inclusion criteria

- Patients ≥18 years
- Patients receiving those requiring mechanical ventilation who met weaning criteria after >48 hours
- A score between -1 and +1 on the Richmond Agitation and Sedation Scale
- Muscle-paralyzing agents discontinued for ≥48 hours
- Given informed written consent from legally authorized representatives of patients

Exclusion criteria

- Patients of neuromuscular diseases
- Disease of the diaphragm, cervical spinal cord, chest wall or tracheostomized patient
- Huge ascites or pregnant patients
- Thoracic and major abdominal surgery post-operative patients
- Dressing on the right lower chest wall hindering the sonographic access
- Patients attendants unwilling to be included

Ethical consideration

The study was approved by the institution's ethics board of DMC to undertake the present study and given it in the appendices.

Statistical analysis

The information was cleaned and entered into SPSS 22.0. The study's findings were expressed using descriptive statistics. The means and standard deviations of continuous variables are presented. Frequency and percentage were used to express categorical data. Student's t-Test was used to compare the means of the two groups. The Chi-Square Test (X2-Test) was used to compare categorical data across sample sizes. Chi-Square Tests and Pearson's correlation tests were used to analyze the associations between the

variables. A significance level of 0.05 was used. Exact binomial 95% CIs were used to compute sensitivity and specificity, two indices of diagnostic accuracy. The overall level of statistical significance was established at $p<0.05$ for the entire investigation.

RESULTS

The study included a group of 89 patients. The age distribution of patients is presented in **Table I**. The study was conducted on a diverse group of patients with a wide range of ages, from 19 to 68 years old. The study found that the average age of male patients was 53.1±7.9 years, with a range of 24-68 years, while the average age of female patients was 52.9±8.2 years, with a range of 19-60 years. The observed difference in age between groups did not reach statistical significance (p=0.219). The majority of our patients fall within the age range of 49 to 58 years, with 24 males and 13 females in this category. Please refer to the table labeled as **Table I** below.

Table I: Study participants' ages by group (n=89).

Age in years	Male (56)	Female (33)	P value
Range	24-68	19-60	
19-28	1	10	
29-38	8	2	
39-48	14	4	
49-58	24	13	
59-68	9	4	
Mean±SD	53.1±7.9	52.9±8.2	0.219^{ns}

Figure 1 shows gender distribution. Out of 89 patients, male patients were 56 (63%) and females were 33 (37.0%) and the male: female ratio is 1.7:1. Sex difference was not statistically significant. See the figure 1 below-

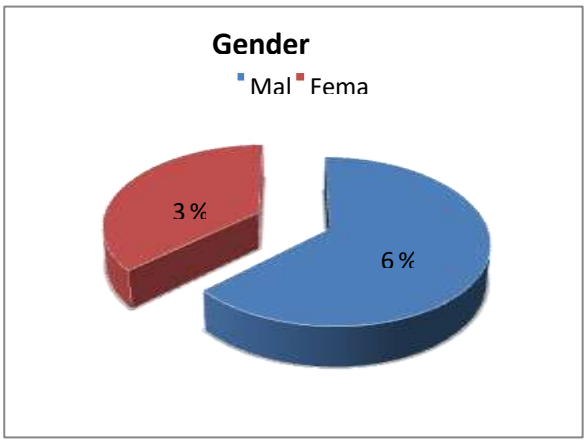

Figure-1: Study participants' gender breakdown (n=89)

Maximum patients were admitted due to sepsis (24.7%), heart failure (19.1%), respiratory failure (14.6%) and head injury (17.9%). In case of female, other indications were PPE (18.1%) and PPH (12.1%). See **Table** II below-

Table II: A breakdown of the patients by their primary reason for being admitted to the intensive care unit (n=89)

Diagnosis	Male(56)		Female (33)		Total (%)
	No.	%	No.	%	
Sepsis	15	26.7	7	21.2	22(24.7)
Heart failure	12	21.4	5	15.1	17(19.1)
PPE	0	0	6	18.1	6(6.7)
PPH	0	0	4	12.1	4(4.5)
Respiratory failure	9	16.0	4	12.1	13(14.6)
Head injury	11	19.6	5	15.1	16(17.9)
Meningo-encephalitis	5	8.9	2	6.0	7(7.8)
Status epileptius	4	7.1	0	0	4(4.5)

The mean respiratory rate (/min) was found 19.5±4.2 in patients of success weaning and 28.5±5.1 in patients of failed weaning. Mean PaO_2/F_IO_2 ratio was found 242.6±7.9 in patients of success weaning and 208.6±5.2 in patients of failed weaning, mean $PaCO_2$ was found 38.2±5.2 in patients of success weaning and 42.6±4.3 in patients of failed weaning, and mean pH was found 7.41±0.5 in patients of success weaning and 7.34±0.8 in patients of failed weaning group. There was no statistically significant difference between the two groups. See **Table III** below-

Table III: Baseline characteristics of clinical parameters (n=89)

Weaning parameters	Predicted group		*p* value
	Success weaning (*n=40*) Mean(SD)	**Failure weaning (*n=49*) Mean(SD)**	
Respiratory rate (/min)	19.5±4.2	28.5±5.1	0.087^{ns}
PaO_2/F_IO_2 ratio	242.6±7.9	208.6±5.2	1.152^{ns}
PaCO2	38.2±5.2	42.6±4.3	0.204^{ns}
pH	7.41±0.5	7.34±0.8	0.081^{ns}

Table IV shows ultrasonographic findings of diaphragm thickness at TLC. Itwas observed 3.7±0.7 mm in successful weaning group and 2.8±0.9 mm in failure weaning group of patients. In the successful weaning group, the diaphragm thickness at TLC was significantly greater than in the unsuccessful weaning group. See the table below-

Table IV: Ultrasonographic evaluation of diaphragm thickness at total lung capacity (TLC) (mm) (n=89)

Diaphragm thicknessat total lung capacity (TLC) (mm)	**Success weaning (*40*)**		**Failure weaning (*49*)**	
	No.	*%*	*No.*	*%*
<2.0	2	5.0	21	42.8
2.1-3.3	23	57.5	18	36.7
3.4-4.5	15	37.5	10	20.4
Mean±SD	3.7±0.7		2.8±0.9	

Table V shows ultrasonographic findings of diaphragm thickness at residual volume (RV) was almost similar. Mean±SD of diaphragm thickness at RV was observed 2.3±0.4 mm in successful weaning group and 2.3±0.6 mm in failure weaning group of patients. Among the weaning success patients, 72.5% data was found in the range between 2.1-3.3mm, whereas 57.1% data of the weaning failure group was found within the same range. See **Table V** below-

Table V: Ultrasonographic evaluation of diaphragm thickness at residual volume (RV) (mm) (n=89)

Diaphragm thickness at residual volume (RV)mm	**Success weaning (*40*)**		**Failure weaning (*49*)**	
	No.	*%*	*No.*	*%*
<2.0	9	22.5	18	36.7
2.1-3.3	29	72.5	28	57.1
3.4-4.5	2	5.0	3	6.1
Mean±SD	*2.3±0.4*		2.3±0.6	

Table VI shows ultrasonographic findings of diaphragm thickening fraction (DTF). In this study, among the predictd successful weaning group 38(95.0%) patients weaned successfully, and 46(93.8%) patients of predicted failure group revealed failure or DTF <30%. Then correlation of diaphragm thickening fraction (DTF) and successful weaning parameter was done. There was a statistically significant correlation in the diaphragm thickening fraction (DTF) and predicted successful weaning parameter ($p < 0.001$). See the table below-

Table VI: Ultrasonographic evaluation of diaphragm thickening fraction DTF%

Diaphragm thickening fraction (DTF) >30%	***Success weaning***	***Failure weaning***	***Total***	***p* value**
Weaning successful ***(41)***	38(92.7%)	3(7.3%)	41*(100%)*	0.001[s]
Weaning failed ***(48)***	2(4.2%)	46(95.8%)	48*(100%)*	0.001[s]
Total	*40*	*49*	*89*	

According to the data presented in Table VII, the diaphragm thickening fraction (DTF) demonstrated a sensitivity of 95.0% and a specificity of 93.8% in predicting the success of weaning. The positive and negative predicative values were both quite high, with the positive value at 92.6% and the negative value at 95.8%. The accuracy rate achieved was quite high at 94.3%. See the table below-

Table VII: Accuracy, negative predictive value, positive predictive value, sensitivity, and specificity

Diaphragm thickening fraction (DTF) >30%	***Success weaning (40)***	***Failure weaning (49)***	***Total***
Weaning successful ***(41)***	38 (TP)	3 (FP)	41
Weaning failed ***(48)***	2 (FN)	46(TN)	48
Total	40	49	89

DISCUSSION

Dia.phragm thickening fraction was investigated in this study as a possible marker of successful weaning from mechanical ventilation. There were a total of 89 people included in the study, with the average male patient being 53.1 ±7.9 years old and the average female patient being 52.9 ±8.2 years old. 1.7:1 male to female ratio. Sepsis, heart failure, brain injuries, and respiratory failure were prevalent among the victims. PPE (18.1%) and PPH (12.1%) were other indications in case of females. the patients' primary disease category, male to female ratio, and age range were all similar [8]. In their analysis, sepsis was the most common medical condition (27%), and 62.5% of the patients were male. Patient's median ages were 66.5 (13.5) years, with 47.1% of men and 52.9% of women [2]. Although the age range was nearly identical, There was a discrepancy between the male and female participation rates in this study. Nearly a third of the study's patients were women, and they were most prevalent between the ages of 18 and 30.

Majority of the patients had sepsis, heart failure, and head injuries, which is another explanation for the greater predicted failure group. Furthermore, the patients' diaphragmatic insufficiency necessitated extended mechanical breathing, increasing RSBI. Other factors that may affect diaphragmatic performance include age, hypercapnia, hypoxia, malnutrition,

therapy with corticosteroids or other drugs, cardiovascular issues, and inactivity [9-11].

Diaphragm thickness at TLC and RV in the successful and failure groups in this study was fairly comparable to that found in other investigations [2,12]. The comparability of these investigations demonstrates the consistency of DTF and diaphragm thickness. Overall results showed that 55.0% of patients expected failure weaning whereas 45% of patients projected successful weaning. The diaphragm thickening fraction (DTF) was then evaluated. In this study, 46 (93.8%) of the patients in the projected failure group indicated failure or DTF<30%, while 38 (95.0%) of the patients in the expected successful weaning group weaned successfully. Next, a link between the successful weaning parameter and the diaphragm thickening fraction (DTF) was carried out. Diaphragm thickening fraction's (DTF) sensitivity and specificity for predicting weaning success were 95.0% and 93.8%, respectively. The positive and negative predictive values, meanwhile, were 92.6% and 95.8%, respectively. A 94.3% accuracy rate was achieved.

In their study, the right and left DTF and the RSBI had respective receiver operating characteristics of 0.951, 0.700, and 0.709 for the prediction of successful weaning (sensitivity of 96%, specificity of 68%, positive predictive value of 89%, negative predictive value of 86%) [2]. Another study found that weaning success was associated sensitivities of 82%, specificities of 88%, positive predictive values of 92%, and negative predictive values of 75% were found for a right DTF of over 36% in a semi-upright position [12]. Because the sample was purposefully collected, this study had superior sensitivity and specificity compared to previous research. The differences in research populations, the effects of prolonged mechanical breathing, electrolyte imbalance, and sepsis may all have contributed to the sensitivity and specificity differences across these studies. The majority of these investigations demonstrated that, in terms of specificity, DTF alone is a more accurate weaning predictor than others. Therefore, identifying patients who are secure and prepared to wean can be done using ultrasound-based diaphragm measurements at different inspiratory efforts [8]. This gives the doctor more confidence when weaning seriously unwell patients. Therefore, it can be concluded the learning curve for using point-of-care ultrasonography to assess diaphragm function is favorable, and the technique helps clinicians decide whether their critically ill patients are stable enough to be taken off life support.

The current study benefits from gathering information from the right DTF, which did not differ from past studies; the significant correlation between the two groups and the lack of wide fluctuation strengthened the conclusions of earlier studies.

CONCLUSION

The results of the current experiment showed that DTF was an efficient measure for successfully weaning patients off of mechanical breathing.

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