ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 09 | September - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A PROSPECTIVE CROSS-SECTIONAL ANALYTICAL STUDY ON ROLE OF DIAPHRAGMATIC ULTRASOUND IN WEANING OFF PATIENT FROM MECHANICAL VENTILATION IN ICU

Anaesthesiology

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ABSTRACT

Background: Weaning patients from mechanical ventilation remains a complex and crucial decision in intensive care units (ICUs). Premature or delayed weaning can result in significant morbidity and mortality. Traditional weaning parameters often fall short in accurately predicting weaning outcomes. Diaphragmatic ultrasound (DUS), by measuring diaphragmatic excursion (DE) and diaphragmatic thickening fraction (DTF), offers a non-invasive, bedside modality to assess diaphragmatic function. **Objectives Of The Study:** To evaluate the role of diaphragmatic ultrasound in predicting successful weaning from mechanical ventilation in ICU patients by assessing diaphragmatic excursion and thickening fraction. **Material And Methods:** This prospective cross-sectional analytical study was conducted in the ICU of Swaroop rani hospital, Prayagraj. A total of 100 mechanically ventilated patients who met standard criteria for weaning were enrolled prior to spontaneous breathing trials (SBT), diaphragmatic ultrasound was performed to measure DE (in cm) and DTF (as percentage). The patients were monitored for weaning outcomes – successful extubation or failure – within 48 hours post-extubation **Results:** Among 100 patients, 66 achieved successful weaning. Mean DE and DTF values were significantly higher in the successfully weaned group compared to those who failed ($p < 0.001$). Receiver Operating Characteristic (ROC) analysis showed DE > 1.2 cm and DTF > 30% as optimal thresholds predicting successful weaning with high sensitivity and specificity. **Conclusion:** Diaphragmatic ultrasound, specifically DE and DTF, is a reliable and practical tool for predicting weaning success. Its incorporation into routine ICU weaning protocols can enhance decision-making and patient outcomes.

KEYWORDS

Diaphragmatic ultrasound, mechanical ventilation, weaning, intensive care unit, diaphragm thickening fraction, spontaneous breathing trial

INTRODUCTION

Invasive mechanical ventilation (MV) is the gold standard intervention for patients with respiratory failure. Its primary objectives are to reduce the work of breathing, maintain adequate oxygenation and ventilation, ensure airway patency, support lung mechanics, and optimize gas exchange. The process of weaning—transitioning patients from MV to spontaneous breathing—is a crucial and often challenging phase in intensive care. Approximately 20% of patients experience difficulties during weaning, which may result in prolonged ventilation and adverse outcomes.Although MV is life-saving, prolonged support may cause ventilator-induced diaphragmatic dysfunction (VIDD), a form of myotrauma that impairs diaphragmatic contractility. Extubation without prior assessment of diaphragmatic function can precipitate respiratory failure and necessitate reintubation. Conversely, delayed extubation increases the risk of complications such as patient–ventilator asynchrony, ventilator-associated pneumonia (VAP), and barotrauma.Weaning success is generally defined as the absence of reintubation within 48 hours following extubation,[5,6] or, as per the WIND study, within 7 days. However, literature suggests that only about 65% of patients achieve successful weaning, highlighting the need for reliable predictive indices. Current guidelines recommend various bedside indices to aid in predicting readiness for weaning. Successful liberation requires adequate oxygenation, stable hemodynamics with minimal vasopressor support, and an intact neurological status to manage airway secretions.

Conventional Weaning Approaches:

Three General Strategies Are Commonly Employed:

- Spontaneous Breathing Trial (SBT) – the oldest and most widely used method,
- Pressure Support Ventilation (PSV), and
- Synchronized Intermittent Mandatory Ventilation (SIMV).

Role Of Diaphragmatic Ultrasound:

In recent years, diaphragmatic ultrasound has emerged as a safe, non-invasive, radiation-free, and easily repeatable bedside tool for assessing diaphragmatic function and predicting weaning outcomes.[10] It provides both morphological and functional data in real time. The diaphragm is the principal respiratory muscle, contributing ~75% of resting pulmonary ventilation. During quiet breathing, excursion ranges from 1–2 cm, while in forced breathing, it may reach 7–11 cm. However, in critically ill patients, factors such as sepsis, hypoxia, and prolonged ventilation predispose the diaphragm to dysfunction, leading to atelectasis, pneumonia, and extubation failure. Early diagnosis of diaphragmatic dysfunction is therefore essential to minimize weaning failure.

MATERIAL AND METHODS:

A Prospective cross-sectional analytical study was carried out in ICU of Swaroop Rani Nehru Hospital associated with Moti Lal Nehru Medical College, Prayagraj with the aims whether ultrasound measurements of DE(Diaphragmatic excursion) and DTF (Diaphragmatic thickness fraction) are accurate predictors of successful extubation from the ventilator throughout the phases of weaning and whether they can make better prediction of effective extubation compared to RSBI, to determine the role of DE and DTF in successful extubation and Comparison of RSBI, DE and DTF among both the groups.

Sample Size:

The sample size was calculated using formula proposed by Snedecor and Cochran: Where n=sample size Z = The Confidence Level n = (Z2 × P × (1-P)) / d2 P = Expected Prevalence and d = Precision (Margin of Error) A 95% confidence level is used, corresponding to a Z-score of approximately 1.96. P based on a previous study[36] is taken as 42.5% and taking margin of 34 error as 10%, the desired sample size came out to be 94 we rounded it off to 100 patients.

Inclusion Criteria:

Age - 18 - 60 years, Sex - male / female, ASA - I & II, Patient is on mechanical ventilation, A stable hemodynamic status, Patient will not be on neuromuscular blocking agent, Patient will not be on sedation, Ready for weaning trial.

Exclusion Criteria:

Age 60 years, Patients with BMI more than or equal to 30kg/m2, Hemodynamic unstable patient, The presence of pneumothorax or ascites, Patient is having neuromuscular disease Patient is on vasopressor, Patient is on sedation, Pregnancy

OBSERVATIONS AND RESULTS

This Prospective cross-sectional analytical study was carried out in Anesthesia ICU of Anesthesia department, Swaroop Rani Nehru Hospital associated with Moti Lal Nehru Medical College, Prayagraj with the aims whether to Determine the role of DE and DTF in successful extubation and Comparison of RSBI, DE and DTF among both the group.

Demographic Characteristics

- **Gender Distribution:** 72 males (72%) and 28 females (28%).
- **Age Distribution:** Majority (55%) were between 18–40 years; mean age was **62.3 ± 21.1 years**.
- **BMI Distribution:** Most patients (47%) had BMI 20.1–25, with mean BMI **23.7 ± 4.1**.

Hemodynamic And Clinical Parameters

- Patients with successful weaning (n=66) had significantly lower heart rate (111.3 vs 138.8, p=0.001),
- higher mean arterial pressure (74.2 vs 56.4, p=0.002),
- lower respiratory rate (23.4 vs 36.5, p=0.001), and
- higher SpO_2 (93.5% vs 83.6%, p=0.001) compared to those with weaning failure (n=34).

Conventional Weaning Parameter

- **RSBI:** Median was **68** (55–82) in success group vs **118** (111–144) in failure group (**p=0.010**).

Diaphragmatic Ultrasound Parameters

- **Diaphragmatic Excursion (DE):** Higher DE was significantly associated with weaning success. Most patients with DE >10 mm were successfully weaned.
- **Diaphragm Thickness At TLC:** Success group showed greater thickness (**0.38 vs 0.30, p=0.010**).
- **Diaphragm Thickness At RV:** Higher in success group (**0.25 vs 0.24, p=0.010**).
- **Diaphragm Thickening Fraction (DTF):** Strongly predictive, with success group showing **0.54 vs 0.27 in failure group (p=0.010)**.

Other Respiratory Indices

- **Respiratory Rate:** 27 vs 32 breaths/min (p=0.001).
- **Maximum Inspiratory Pressure (MIP):** Significantly higher in success group (**85.4 vs 43.2, p=0.001**).
- **Expiratory Tidal Volume:** Higher in success group (**363 mL vs 290 mL, p=0.015**).

ICU And Ventilator Stay

- **ICU Length Of Stay:** 14.3 ± 8.6 days (success) vs 23.5 ± 7.2 days (failure), p=0.008.
- **Duration On Ventilator:** 25.2 ± 6.7 days (success) vs 39.4 ± 9.2 days (failure), p=0.002.

Complications In Weaning Failure (n=34)

- **Aspiration:** 50%
- **Reintubation:** 29.4%
- **Respiratory Distress:** 20.6%

(Aspiration was statistically significant, p=0.011).

Overall Weaning Success Rate

- 66% (66 patients) were successfully weaned.
- 34% (34 patients) experienced weaning failure.

Key Findings

1. Diaphragmatic excursion and thickening fraction were significantly higher in successfully weaned patients.
2. DTF proved to be the strongest predictor of successful weaning compared to RSBI and other conventional indices.
3. Weaning failure was associated with longer ICU stay, longer ventilator use, and higher complication rates.
4. Overall success rate was 66%.

CONCLUSION:

The Prospective cross-sectional analytical study was carried out in Anesthesia ICU of Swaroop Rani Nehru Hospital associated with Moti Lal Nehru Medical College, Prayagraj. In our study we included 18 - 60 years patients, ASA I & II , who were on mechanical ventilation and had stable hemodynamic status. Majority of male patients were participated in this study. In our study we observed significant relationship between weaning success and weaning failure subjects in respect of Heart Rate, Mean Arterial Pressure, Respiratory Rate, SPO2, Rapid shallow breathing index, Diaphragmatic excursion, Diaphragm thickness at total lung capacity, Diaphragm thickness at residual volume, Diaphragm thickness fraction, Maximum inspiratory pressure, Expiratory tidal volume, Length of stay in ICU, duration of patients on ventilator and complications occurred in failure patients. Ventilated patients planned for extubation and revealed that longer ICU duration had statistically significant higher rate of extubation failure. A diaphragm dysfunction was diagnosed by ultrasound if an excursion<10mm or a paradoxical movement was observed. Diaphragmatic dysfunction was associated with weaning failure.The current study revealed that lower DTF was significantly linked to failure of extubation. In our study diaphragm excursion in weaning success patients and weaning failure was significantly relate.

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