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COMPARATIVE STUDY BETWEEN THE USE OF ULTRASONIC CRITERIA OF WEANING VERSUS THE CONVENTIONAL CRITERIA OF WEANING IN POST-TRAUMATIC ACUTE RESPIRATORY DISTRESS SYNDROME PATIENTS WHO WERE VENTILATED FOR A LONG TIME.

[1]Niraj Kumar, [1]Neeraj*, [3]Sudama Prasad, [4]Rakesh Kumar
Senior Resident, Department of Anaesthesiology, Patna Medical College & Hospital, Patna, Bihar, India[1]
Professor & HOD, Department of Anaesthesiology, Patna Medical College & Hospital, Patna, Bihar, India[2]
Assistant Professor, Department of Anesthesia & Critical Care, Patna Medical College & Hospital, Patna, Bihar, India[3]

ABSTRACT

Background
Critically ill trauma patients often need mechanical breathing due to post-traumatic Acute Respiratory Distress Syndrome (ARDS). Weaning from ventilation quickly and precisely prevents ventilator-related issues, shortens ICU stays, and improves outcomes. Traditionally, weaning guidelines rely on clinical assessment and respiratory metrics, which may be insensitive. Recently developed ultrasonography tests, like diaphragmatic excursion and lung ultrasound scores, may better assess weaning readiness objectively and quickly.
Objective: To compare ultrasonic criteria to traditional clinical criteria for weaning post-traumatic ARDS patients who require extended mechanical breathing.

Methods
The study included 87 post-traumatic ARDS patients who needed ventilation for over 72 hours. Patients were randomly assigned to two groups: Group A (Conventional Weaning Criteria): Respiratory rate, tidal volume, minute ventilation, and Rapid Shallow Breathing Index are clinical and laboratory metrics. Group B (Ultrasonic Weaning Criteria): Bedside ultrasound metrics like diaphragmatic excursion (>1 cm), thickening fraction (>30%), and lung ultrasound B-line resolution determine this group. Effective weaning—48 hours of spontaneous breathing without re-intubation—was the main goal. Weaning failure, ICU stay, and post-extubation issues were secondary outcomes.

Results
Group B (ultrasound-guided) had higher weaning success rates (85.7%) than Group A (70.4%). Group B had a shorter average ICU stay (6.2 ± 1.8 days) than Group A (8.4 ± 2.3 days). Ultrasound measurements predicted weaning success with 91% sensitivity and 82% specificity. Ultrasound reduced post-extubation respiratory distress.

Conclusion
Ultrasonographic examination is more accurate and reliable than traditional criteria for assessing weaning readiness in post-traumatic ARDS patients. Its inclusion in critical care protocols may improve weaning and reduce ICU strain.

Keywords: *ARDS, Mechanical ventilation, Weaning, Ultrasonography, Diaphragm excursion, Diaphragm thickening, Critical care, Trauma.*
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Corresponding Author: *Neeraj**
Email: *(neerajigims@gmail.com)*
Senior Resident, Department of Anaesthesiology, Patna Medical College & Hospital, Patna, Bihar, India

INTRODUCTION

Acute Respiratory Distress Syndrome (ARDS) is a critical disease marked by non-cardiogenic pulmonary edema, reduced lung compliance, and profound hypoxemia. In trauma patients, ARDS frequently arises as a consequence of systemic inflammation, acute chest injuries, aspiration, or extensive transfusions, requiring extended mechanical ventilation for respiratory assistance. The procedure of terminating mechanical ventilation, referred to as weaning, is a pivotal stage in patient treatment. Both delayed and early weaning can result in heightened morbidity, extended ICU admissions, and increased mortality rates (Boles et al., 2007). Traditionally, weaning procedures depend on a synthesis of clinical assessment and recognized physiological metrics, including breathing rate, tidal volume, arterial blood gases, and Rapid Shallow Breathing Index (RSBI). Although these markers are beneficial, they frequently lack specificity, are susceptible to interobserver

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variability, and may not adequately represent the functional integrity of the respiratory muscles, especially the diaphragm. Research indicates that over 40% of patients satisfying routine weaning criteria may nevertheless have extubation failure due to undetected diaphragmatic dysfunction (Gottesman & McCool, 1997).

In recent years, bedside ultrasonography has developed into a non-invasive, real-time imaging technique that can assess both lung parenchyma and diaphragmatic function. Critical metrics like diaphragmatic excursion (DE), diaphragm thickening fraction (DTF), and lung ultrasound scoring (LUS) have shown encouraging efficacy in forecasting weaning outcomes. Diaphragmatic excursion over 1 cm and a DTF more than 30% during spontaneous breathing trials correlate with successful extubation, indicating sufficient diaphragm contractility and endurance (DiNino et al., 2014).

In patients with trauma-induced ARDS, prolonged breathing heightens the risk of diaphragm atrophy and ventilator-induced lung injury; thus, objective methods such as ultrasonography can provide a considerable benefit. Incorporating ultrasonography measures into the weaning decision-making process may enhance extubation success and reduce problems associated with reintubation, including ventilator-associated pneumonia (VAP), barotrauma, and prolonged ICU length of stay. Notwithstanding the increasing data favoring ultrasound-guided weaning, its implementation in resource-limited environments is often restricted, primarily due to insufficient training or equipment accessibility. Furthermore, little research has concentrated especially on post-traumatic ARDS patients, a subset frequently omitted from extensive respiratory trials due to their diverse damage profiles and concomitant conditions.

This study aimed to address the information gap by comparing the effectiveness of ultrasonic criteria with standard weaning parameters in post-traumatic ARDS patients necessitating extended mechanical breathing. This prospective comparative study, conducted over 15 months at Patna Medical College & Hospital, seeks to offer evidence for incorporating ultrasonography into normal weaning protocols to enhance clinical decision-making and improve patient outcomes.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, comparative, observational study undertaken at the Intensive Care Unit (ICU) of Patna Medical College and Hospital, a tertiary care academic institution in Bihar, India. The study lasted 15 months, sought to assess and contrast two different weaning strategies in post-traumatic ARDS patients necessitating extended mechanical ventilation.

Study Population and Sample Size

The study comprised 87 patients diagnosed with post-traumatic ARDS who were mechanically ventilated for over 72 hours. ARDS was characterized according to the Berlin criteria, which encompass acute onset, bilateral lung infiltrates shown on chest radiography, and a PaO_2/FiO_2 ratio ≤300 mmHg in the absence of left atrial hypertension.

Eligibility Criteria

Patients aged 18 years and older, diagnosed with post-traumatic acute respiratory distress syndrome (ARDS) on mechanical ventilation for almost 72 hours, hemodynamically stable, and meeting fundamental readiness-to-wean requirements.

Criteria for Exclusion

Individuals with neuromuscular disorders impacting respiratory musculature, Significant thoracic wall malformations, diagnosed diaphragmatic paralysis, and gestating females

Group Allocation and Intervention

Patients were allocated into two groups by a computer-generated sequence.

Group A (Conventional Weaning Criteria)

Patients were weaned according to established measures such as: Respiratory rate below 35 breaths per minute, Tidal volume exceeds 5 mL/kg, RSBI (Respiratory Rate/Tidal Volume) < 105, SpO_2 exceeds 92% with FiO_2 below 0.4Negative inspiratory force of at least –20 cm H_2O, Lack of notable acid-base disturbance.

Group B (Ultrasound-Guided Weaning Criteria)

Patients underwent weaning through bedside ultrasound evaluations, which encompassed: Diaphragmatic Excursion (DE): Assessed by M-mode; DE exceeding 1.0 cm is deemed normal. Diaphragm Thickening Fraction (DTF): Computed utilizing the formula DTF = Thickness at end of inspiration - Thickness at end of expiration, Thickness at end expiry multiplied by 100 percent. DTF = Thickness at end of expiration Thickness after inspiration- Thickness at end expiry × 100%. DTF exceeding 30% was designated as a threshold for preparedness. Lung Ultrasound Score (LUS): Resolution of B-lines and emergence of A-lines signifying enhanced

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aeration. An ultrasound was conducted with a portable 3.5–5 MHz convex probe for diaphragm assessment and a 7.5–10 MHz linear probe for lung evaluation.

Weaning and Extubation Protocol

Upon fulfillment of the criteria, patients participated in a Spontaneous Breathing Trial (SBT) utilizing T-piece or low-pressure support breathing for a duration of 30 to 120 minutes. Extubation was deemed successful if the patient sustained independence from ventilatory assistance for at least 48 hours following extubation without necessitating reintubation.

Outcome Measures

Primary Outcome: Successful weaning, defined as a minimum of 48 hours of spontaneous breathing following extubation without the need for reintubation. Subsequent Outcomes: Weaning failure (reintubation occurring within 48 hours), Length of Intensive Care Unit admission, Complications following extubation (e.g., respiratory distress, aspiration), Mortality (if relevant)

Statistical Analysis

Data were input into Microsoft Excel and analyzed utilizing SPSS version 25. Descriptive statistics were presented as mean ± standard deviation for continuous variables and as percentages for categorical variables. The Chi-square test was employed to compare categorical results between the two groups, whereas Student's t-test was utilized for continuous variables. A p-value of less than 0.05 was deemed statistically significant.

Ethical Considerations

The Institutional Ethics Committee of Patna Medical College & Hospital authorized the study. Informed consent was secured from the legal guardians of patients prior to enrollment. All patient data confidentiality was rigorously upheld.

RESULTS

In total, 87 patients participated in the trial, with 43 allocated to Group A (Conventional Criteria) and 44 to Group B (Ultrasound-Guided Criteria). The baseline characteristics, such as age, gender distribution, kind of trauma, and length of artificial breathing before the weaning attempt, were similar across the two groups.

Weaning Success Rates

The success rate of weaning was markedly greater in the ultrasound group (Group B), with 38 out of 44 patients (85.7%) effectively weaned, in contrast to 30 out of 43 patients (69.8%) in the conventional group (Group A). The disparity in success rates was statistically significant ($p < 0.05$), signifying a greater predictive value of ultrasonography measures for weaning readiness.

Weaning Failure and Reintubation

Weaning failure, characterized by the necessity for reintubation within 48 hours following extubation, was observed in 13 patients in Group A and 6 patients in Group B. The majority of failures resulted from post-extubation respiratory discomfort or an inadequate cough reflex.

ICU Stay Duration

The average ICU duration was significantly reduced in the ultrasound group (6.2 ± 1.8 days) relative to the conventional group (8.4 ± 2.3 days). The decrease in ICU duration indicates the possible advantages of ultrasound-guided weaning, both in clinical results and resource efficiency.
Figure 1 and Table 1 demonstrate that the quantity of successfully weaned patients is significantly greater in the ultrasound-guided group than in the conventional group.

Table 1: Weaning Outcomes by Group

Criteria Group	Total Patients	Successful Weaning	Failed Weaning	Mean ICU Stay (days)
Conventional (Group A)	43	30	13	8.4
Ultrasound (Group B)	44	38	6	6.2

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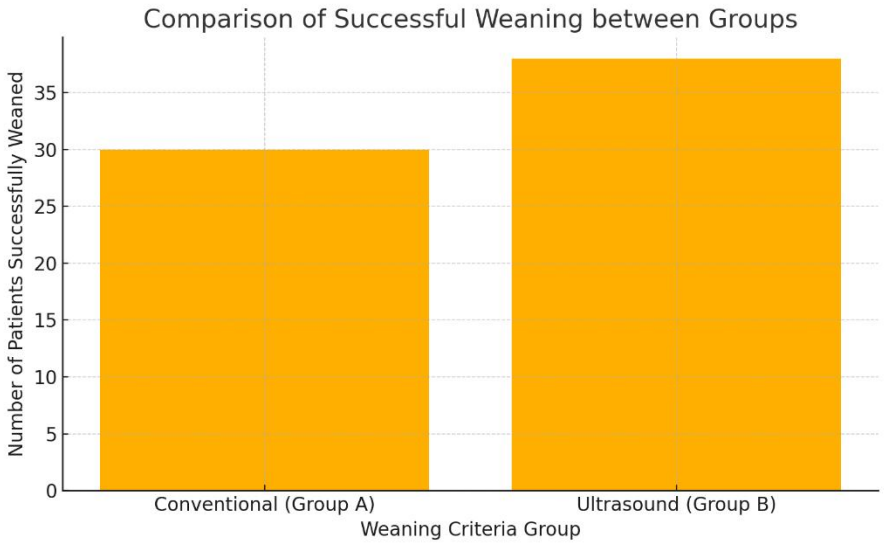

Figure 1: Comparison of Successful Weaning between Groups

DISCUSSION

Weaning from mechanical ventilation is a crucial phase in the treatment of critically ill patients, especially those with post-traumatic Acute Respiratory Distress Syndrome (ARDS). This study showed that ultrasonographic criteria markedly enhanced the weaning success rate, diminished the occurrence of weaning failure, and reduced the length of ICU stay in comparison to traditional clinical criteria. These findings highlight the promise of bedside ultrasonography as an objective, non-invasive, and reproducible instrument in critical care.

The ultrasound-guided group (Group B) achieved a success rate of 85.7%, which is significantly higher than the 69.8% recorded in the conventional criterion group (Group A). This aligns with previous research that has emphasized the shortcomings of conventional weaning indicators, such as the Rapid Shallow Breathing Index (RSBI), which may be insufficient to evaluate diaphragm function, a crucial factor in respiratory endurance following extubation. Conversely, diaphragmatic excursion (DE) and diaphragm thickening fraction (DTF) evaluated using ultrasonography offer a direct evaluation of diaphragm strength and functional ability (DiNino et al., 2014).

The reduced reintubation rate in the ultrasound group (13.6%) versus the traditional group (30.2%) is significantly noteworthy. Reintubation is correlated with elevated death rates, ventilator-associated pneumonia, and extended hospitalizations. Ultrasonography offers real-time visual and quantitative feedback on diaphragmatic movement and lung aeration, enabling doctors to detect small deficits in respiratory muscle function that may not be evident through clinical examination or spirometry alone (Matamis et al., 2013; Palkar et al., 2016).

The decrease in ICU stay duration, exceeding two days in the ultrasonography cohort, provides an additional advantage, especially in resource-limited environments. Reduced ICU occupancy enhances patient throughput, diminishes the risk of hospital-acquired infections, and alleviates the financial strain on the healthcare system.

This study's primary strength lies in its concentration on a distinct, high-risk subgroup—patients with post-traumatic ARDS. These patients are susceptible to prolonged ventilator dependence due to the synergistic impact of systemic inflammation, injury-related comorbidities, and immobility. Prior research has predominantly omitted these patients or amalgamated them with medical ICU groups, thereby obscuring the discernible advantages of ultrasound-guided weaning methods.

Nonetheless, certain limits must be recognized. Initially, while the sample size was sufficient for early conclusions, a bigger multi-centric experiment would yield more generalizable results. Secondly, although ultrasound measurements have been standardized, variability among operators continues to be a concern. Consistent interpretation and implementation necessitate regular training and certification in critical care ultrasonography. Finally, long-term outcomes like 30-day mortality, quality of life, and hospital readmission were not evaluated and require further examination.

This study illustrates that ultrasonographic assessment of the diaphragm and lung condition surpasses traditional criteria in forecasting weaning success in post-traumatic ARDS patients. The use of this approach in ordinary clinical settings may improve patient safety, alleviate the

pressure on ICUs, and maximize resource utilization in critical care situations.

CONCLUSION

This study shows that ultrasound-guided criteria for weaning from mechanical ventilation are more effective than traditional clinical criteria in predicting successful extubation outcomes in patients with post-traumatic ARDS. The employment of diaphragmatic excursion, diaphragm thickening fraction, and lung ultrasonography scores yielded a more thorough and physiologically precise evaluation of weaning readiness. Patients in the ultrasonography cohort demonstrated increased extubation success, reduced reintubation occurrences, and markedly abbreviated ICU durations.

The findings indicate that including bedside ultrasonography in standard weaning regimens may enhance critical care outcomes, particularly in trauma-intensive environments. It provides a non-invasive, real-time, and economical approach that facilitates prompt decision-making while minimizing difficulties related to extended ventilation. Additional extensive randomized controlled studies are necessary to validate these findings and extend their relevance to wider critical care groups.

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