**Original Article**

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# Bedside Diaphragmatic Ultrasonography as a Predictor of Successful Weaning from Mechanical Ventilation

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**ABSTRACT**

**Objective:** To assess the predictive value of diaphragmatic ultrasound for successful weaning from mechanical ventilation.

**Methodology:** This cross-sectional validation study was conducted in the ICU at PIMS from November 2023 to April 2024, on mechanically ventilated patients aged 16–60 years with a pre-illness frailty score of <3 who met weaning criteria. After a successful 1-hour spontaneous breathing trial (SBT), the Rapid Shallow Breathing Index (RSBI) was recorded, and diaphragm ultrasound was performed by an independent anesthetist to measure diaphragmatic excursion (DE) and diaphragm thickening fraction (DTF). Ultrasound assessments were done using curvilinear and linear probes in a semi-recumbent position. Maintaining the spontaneous breathing for 48 hours post-extubation was defined as successful weaning, while failure was defined as needing re-intubation within 48 hours. Data were analyzed using SPSS version 26.

**Results:** Overall average age of patients was 37.82 years. There were 19 (28.8%) females and 47(71.2%) males. Mean days on mechanical ventilator was 5.48 days. The outcomes of weaning showed that 59 participants (89.4%) were successfully weaned, while 7 participants (10.6%) experienced failure in the weaning process. Further analysis of outcomes of weaning showed insignificant association with the gender and (P>0.05).

**Conclusion:** Diaphragmatic ultrasound provided a comprehensive assessment of diaphragmatic function and its role in predicting weaning outcomes. The high success rate suggests that diaphragmatic ultrasound could be a valuable tool in clinical practice for identifying patients who are likely to be successfully weaned from mechanical ventilation, thereby improving patient management and outcomes.

**Keywords:** Mechanical ventilation, Weaning, Success, Diaphragmatic, DTF, DE, RSBI.

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## Introduction

Mechanical ventilation (MV), a life-sustaining assistance provided in intensive care units (ICUs), is an important supportive care procedure for respiratory failure, and is required in around 40% of patients admitted to ICUs.[1] However, if mechanical ventilation (MV) is provided for a longer period of time, can lead to a higher risk of several complications, such as ventilator-induced lung injury (VILI), intensive care unit-acquired weakness (ICUAW), oxygen toxicity, nosocomial pneumonia, and ventilator-induced diaphragm dysfunction (VIDD), leading to prolonged hospitalization and high mortality rates.[2] These threatening complications necessitate comprehensive assessment of patients, with promptly determining the optimal point of weaning to minimize failure risk of weaning.[3,4]

Diaphragmatic dysfunction and respiratory muscle are among the significant contributors to MV-associated

unsuccessful weaning, despite other factors including impairment of pulmonary and respiratory airway, cardiac insufficiency, and cerebral dysfunction.[5] Thus, successful weaning can be achieved through constant monitoring for diaphragmatic functions and preemptive administration of underlying medical conditions.

Diaphragmatic ultrasonography has been extensively studied in predicting successful weaning from MV. A recent systematic review and meta-analysis conducted by Parada-Gereda et al.[6] concluded that diaphragmatic ultrasound can predict success of weaning from MV through measuring the diaphragmatic thickening fraction and diaphragmatic excursion, with acceptable diagnostic accuracy. Diaphragmatic ultrasound was reported to have specificity 80% and sensitivity 80% for diaphragmatic excursion, and sensitivity 85% and specificity 75% for thickening fraction, with heterogeneous findings observed in included studies. Another recent study conducted by Al-Husinat et al.[7] concluded that ultrasonography is a non-invasive and readily available imaging modality, and a promising bedside-accessible method for weaning assessment. This integration can possibly lowering the likelihood of weaning failure and its related complications in critically ill patients.

Diaphragmatic ultrasonography in elderly populations, where decline in pulmonary functions is prevalent, is particularly promising.[8] According to a study by Li et al.[9] concluded that in assessing the risk of negative outcomes can be improved by bedside ultrasonography monitoring the DTF and DE and it can predict the success rate of weaning in critically ill elderly patients on mechanical ventilation in ICU, with highest specificity and sensitivity found for DTF.[9]

Moreover, advanced ultrasonographic techniques have also been investigated for their potential in enhancing weaning predictions. Such as, in the study by Li et al.[10] found that despite feasible application of speckle tracking ultrasound in assessing diaphragmatic function among patients on mechanical ventilation, combining speckle tracking ultrasound with traditional measures like diaphragmatic excursion improved the accuracy of predicting weaning outcomes.

Standardizing of ultrasonographic assessment protocols and establishing universally accepted cutoff values for diaphragmatic parameters is still challenging irrespective of advancements in assessing diaphragmatic function. Inconsistent findings and variable measurement techniques necessitate further research to validate the application of diaphragmatic ultrasonography in diverse clinical settings. This study was therefore intended to assess bedside diaphragmatic ultrasonography as a predictor of successful weaning from mechanical ventilation.

# Methodology

This cross-sectional validation study was conducted over six months in the adult Intensive Care Unit (ICU) of Pakistan Institute of Medical Sciences (PIMS), Islamabad, after obtaining ethical approval from the hospital's Institutional Review Board Ref No F.3-1/2023(ERRB)/Chairman. Study was conducted during six months from November 2023 to April 2024. All the patients aged 16 to 60 years, with a pre-illness frailty score of less than 3, who were on mechanical ventilation for more than 24 hours and fulfilled standard weaning criteria were included. These criteria included successful completion of a 1-hour spontaneous breathing trial (SBT), stable hemodynamics without inotropic support, a GCS score of 10T/15, effective cough, and satisfactory respiratory values ($FiO_2 < 0.5$, PEEP < 5 $cmH_2O$, $PaO_2 >$ 60 mmHg, $PaCO_2 <$ 50 mmHg, P/F ratio > 200, and respiratory rate < 30). Patients with neuromuscular disorders (e.g., myasthenia gravis, Guillain-Barré syndrome), diaphragmatic palsy, prior thoracic surgery, ascites, pregnancy, or major burns were excluded. A sample of 65 patients was selected based on a calculated sample size, using a confidence level of 95%, alpha of 5%, beta of 20%, and anticipated sensitivity and specificity of diaphragmatic excursion (DE > 1.2 cm) at 94.1% and 82.6%, respectively, with a desired precision of 10%. Informed consent was obtained from all eligible patients or their legal guardians after providing a clear explanation of the study purpose. Only those patients who met the predefined inclusion criteria and voluntarily agreed to participate were enrolled in the study. Confidentiality of patient data was maintained throughout the research process.

This was an observer-blinded study, where the intensivist responsible for making weaning decisions was blinded to both the Rapid Shallow Breathing Index (RSBI) and diaphragm ultrasound findings. RSBI was calculated by the bedside nurse after the patient successfully completed the SBT, and the values were recorded but not shared with the treating team. Diaphragm ultrasound was then performed by a single independent anesthetist with more than 10 years of ultrasound experience. Patients were positioned in a semi-recumbent posture at a 45° head-up angle. A 3–5 MHz curvilinear probe was placed in the

right subcostal margin in B-mode to visualize the dome of the diaphragm. Patients were instructed to take a deep breath in and then exhale fully. DE was measured in M-mode by recording the maximum displacement from baseline in centimeters. DTF was assessed using a 7 MHz linear probe placed between the anterior and mid-axillary lines at the 8th or 9th intercostal space on the right side to visualize the zone of apposition. Diaphragm thickness at full inspiration (TDmax) and expiration (TDmin) was recorded in M-mode, and DTF was calculated using the formula: DTF = [(TDmax – TDmin)/TDmin] × 100, expressed as a percentage. Weaning was defined as successful if the patient remained off mechanical ventilation for at least 48 hours post-extubation, while weaning failure was defined as the need for reintubation or ventilator support within 48 hours. All data were entered and analyzed using SPSS version 26. Patients were grouped into successful and failed weaning categories for comparative analysis of diaphragm ultrasound indices.

# Results

A total of 66 patients were studied in the study, with male gender predominance 47 (71.2%) and 19 (28.8%) were females. Overall mean age of the participants was 37.81 ± 14.70 years and majority of the patients (59.1%) were in the 20–40 years age group as showed in Table I.

**Table I: Descriptive statistics for age and gender. (n=66)**

| Variables | N | % |
|---|---|---|
| **Gender** | | |
| Females | 19 | 28.8 |
| Males | 47 | 71.2 |
| Total | 66 | 100.0 |
| **Age groups** | | |
| 20-40 years | 39 | 59.1 |
| 41-60 years | 20 | 30.3 |
| >60 years | 7 | 10.6 |
| Total | 66 | 100.0 |
| Mean ± SD | 37.81± 14.70 years | |

Out of all patients, 59 (89.4%) were successfully weaned from mechanical ventilation, while 7 (10.6%) experienced weaning failure, indicating a high overall success rate of weaning in the study population. (Figure 1)

Average duration of mechanical ventilation was slightly longer in the failure group 6.33 ± 2.58 days compared to the success group 5.37 ± 3.35 days (p = 0.499). Additionally, the maximum and minimum diaphragm thickness did not show significant differences between the two groups (p = 0.407 and p = 0.317, respectively). While significant differences were observed in key predictive parameters like patients with successful weaning had a significantly higher DTF (52.34 ± 8.24%) compared to those who failed (34.83 ± 3.43%, p = 0.001). Similarly, diaphragmatic excursion (DE) was greater in the success group (1.62 ± 0.26 cm) than in the failure group (0.84 ± 0.13 cm, p = 0.001). Furthermore, the RSBI was significantly lower in successfully weaned patients (62.46 ± 4.28) compared to those who failed (84.83 ± 6.37, p = 0.001). Overall findings suggest that DTF, diaphragmatic excursion, and RSBI are strong predictors of successful weaning from mechanical ventilation as shown in Table II

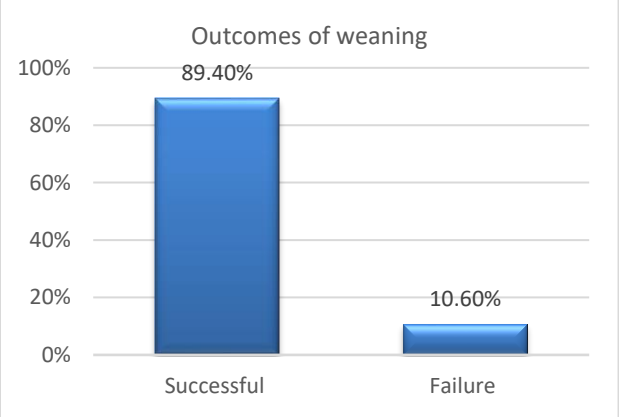


**Figure 1. Outcomes of weaning. (n=66)**

**Table II: Bedside diaphragmatic US predictor for weaning outcomes. (n=66)**

| Bedside diaphragmatic US Features | Outcome | N | Mean | Std. Deviation | p-value |
|---|---|---|---|---|---|
| Duration of ventilation | success | 59 | 5.37 | 3.352 | 0.499 |
| | Failure | 6 | 6.33 | 2.582 | |
| Maximum thickness of the diaphragm (mm) | Success | 59 | .40 | 0.059 | 0.407 |
| | Failure | 6 | .38 | 0.048 | |
| Minimum thickness of the diaphragm (mm) | success | 59 | .26 | 0.042 | 0.317 |
| | Failure | 6 | .28 | 0.037 | |
| Diaphragmatic thickening fraction (%) | success | 59 | 52.34 | 8.243 | 0.001 |
| | Failure | 6 | 34.83 | 3.430 | |
| Diaphragmatic excursion (cm) | Success | 59 | 1.62 | 0.256 | 0.001 |
| | Failure | 6 | .84 | 0.132 | |
| RSBI (breaths/min/L) | Success | 59 | 62.46 | 4.276 | 0.001 |
| | Failure | 6 | 84.83 | 6.369 | |

However, the weaning outcomes showed no significant link with age and the gender (p=>0.05). (Table III)

**Table III: Weaning outcome according to age and gender. (n=66)**

| Variables | Outcome of Weaning | | Total | p-value |
|---|---|---|---|---|
| | Failure | Successful | | |
| **Age group** | | | | |
| 20-40 years | 6 | 33 | 39 | 0.289 |
| | 9.1% | 50.0% | 59.1% | |
| 41-60 years | 1 | 19 | 20 | |
| | 1.5% | 28.8% | 30.3% | |
| >60 years | 0 | 7 | 7 | |
| | 0.0% | 10.6% | 10.6% | |
| **Gender** | | | | |
| Female | 2 | 17 | 19 | 0.898 |
| | 3.0% | 25.8% | 28.8% | |
| Male | 5 | 42 | 47 | |
| | 7.6% | 63.6% | 71.2% | |

# Discussion

Delayed weaning from MV is frequently associated with increased risk for deaths among patients admitted in ICUs and MV-associated serious complications.[11,12] Therefore, accurate assessment of weaning outcomes in patients on ventilator in ICU is of paramount importance in clinical settings to improve survival outcomes.[15] This study assessed the role of bedside diaphragmatic ultrasonography as a predictor of successful weaning from mechanical ventilation. A total of 66 patients were included in the study, with male gender predominance 47 (71.2%) and 19 (28.8%) were females. Overall mean age of the participants was 37.81 ± 14.70 years and majority of the patients (59.1%) were in the 20–40 years age group. The demographic findings of our study are partially supported by the published literature, as most studies included elderly population and male gender only.[14,15]

In our cohort, 59 patients (89.4%) were successfully weaned from mechanical ventilation, while only 7 patients (10.6%) experienced weaning failure, indicating a high overall success rate within the study population. In comparison, Pham et al.[16] reported a lower weaning success rate of 65% at 90 days, with a higher weaning failure rate of 15.6%. They attributed weaning failure to delayed initiation of the weaning process and elevated sedation scores. Similarly, Cohen et al.[17] observed a weaning success rate of just 19% among patients who were functionally independent prior to ventilation. In another study by Bonnici et al.,[18] the weaning success rate was also 19% among 348 patients, with a notably high in-hospital mortality rate of 60%. These findings highlight the variability in weaning outcomes across different settings and patient populations, possibly influenced by factors such as timing of weaning, patient selection, and clinical management strategies.

In our study, the average duration of mechanical ventilation was slightly longer in the weaning failure group ($6.33 \pm 2.58$ days) compared to the success group ($5.37 \pm 3.35$ days), although the difference was not statistically significant (p = 0.499). These findings are consistent with the study by Lin et al.,[19] who reported that patients in the weaning failure group had a significantly longer duration of mechanical ventilation ($31.7 \pm 26.2$ days) compared to those who were successfully weaned ($11.2 \pm 11.6$ days), with a p-value < 0.001. Consistently, study by Vieira et al.[20] found that patients who failed weaning had significantly longer ICU stays ($19 \pm 14$ days) compared to those who succeeded ($13 \pm 12$ days), (p= 0.001. These findings suggest a potential association between prolonged mechanical ventilation and weaning failure, as extended ICU stays are often linked to increased duration of ventilatory support.[21]

In this study, there were no significant differences in maximum and minimum diaphragm thickness between the successful and failed weaning groups (p = 0.407 and p = 0.317, respectively), while significant differences were observed in key predictive parameters. Patients who were successfully weaned had a significantly higher DTF ($52.34 \pm 8.24\%$) compared to those who failed weaning ($34.83 \pm 3.43\%$, p = 0.001). Similarly, DE was notably greater in the success group ($1.62 \pm 0.26$ cm) than in the failure group ($0.84 \pm 0.13$ cm, p = 0.001). The Rapid Shallow Breathing Index (RSBI) also showed a significant difference, being lower in the success group ($62.46 \pm 4.28$) compared to the failure group ($84.83 \pm 6.37$, p = 0.001). These findings suggest that DTF, DE, and RSBI are strong and reliable predictors of successful weaning from mechanical ventilation. In alignment to this study, Parada-Gereda et al.[6] reported that DTF had a sensitivity of 85% and specificity of 75% in predicting weaning success, with an area under the ROC curve of 0.87, indicating good diagnostic accuracy. Consistently, Hayat et al.[22] found that a diaphragmatic excursion of $\geq 1.2$ cm was associated with successful weaning, showing a sensitivity of 78.95% and specificity of 70.83%.

In line with our findings on RSBI, a recent study by Swamy et al.[23] reported that an RSBI cutoff of 90 breaths/min/L demonstrated a sensitivity of 93.33% and a specificity of 100% for predicting successful weaning.

These findings collectively reinforce the utility of diaphragmatic ultrasound indices and RSBI as effective, non-invasive tools for guiding weaning decisions in mechanically ventilated patients. In our study, weaning outcomes showed no significant association with age or gender ($p > 0.05$). Similarly, Fradkin et al.[24] found no significant age differences between successfully and unsuccessfully weaned groups. Supporting this, Ma et al.[25] observed that while male gender was independently associated with higher hospital mortality among elderly patients, age alone was not a standalone predictor of successful weaning.

# Conclusion

Bedside diaphragmatic ultrasonography, particularly measurements of diaphragmatic thickening fraction and excursion, observed to be as effective predictor of successful weaning from mechanical ventilation, as these parameters showed significant differences between successful and failed weaning groups. Incorporating diaphragmatic ultrasound into routine assessments may improve weaning decisions and patient outcomes. Further studies are recommended to confirm these findings and standardize its clinical use.

# References


1. Su D, Li R, Chen Z, Cui N, Yu Z, Ding X, et al. Integration of diaphragmatic ultrasonography and intra-abdominal pressure measurement for optimizing weaning from mechanical ventilation. Risk Manag Healthc Policy. 2025 Dec 31:1547–56. https://doi.org/10.2147/RMHP.S502810
2. Manrique S, Ruiz-Botella M, Murillo N, Canelles S, Victoria ID, Samper MA, et al. Impact of mechanical power on ICU mortality in ventilated critically ill patients: a retrospective study with continuous real-life data. Eur J Med Res. 2024 Oct 7;29(1):491. https://doi.org/10.1186/s40001-024-02082-1
3. Akella P, Voigt LP, Chawla S. To wean or not to wean: a practical patient-focused guide to ventilator weaning. J Intensive Care Med. 2022 Nov;37(11):1417–25. https://doi.org/10.1177/08850666221095436
4. Azizi BA, Munoz-Acuna R, Suleiman A, Ahrens E, Redaelli S, Tartler TM, et al. Mechanical power and 30-day mortality in mechanically ventilated, critically ill patients with and without Coronavirus Disease-2019: a hospital registry study. J Intensive Care. 2023 Apr 6;11(1):14. https://doi.org/10.1186/s40560-023-00662-7
5. Barbariol F, Deana C, Guadagnin GM, Cammarota G, Vetrugno L, Bassi F. Ultrasound diaphragmatic excursion during non-invasive ventilation in ICU: a prospective observational study. Acta Biomed. 2021 Jul 1;92(3):e2021269.
6. Parada-Gereda HM, Tibaduiza AL, Rico-Mendoza A, Molano-Franco D, Nieto VH, Arias-Ortiz WA, et al. Effectiveness of diaphragmatic ultrasound as a predictor of successful weaning from mechanical ventilation: a systematic review and meta-analysis. Crit Care. 2023 May 5;27(1):174. https://doi.org/10.1186/s13054-023-04430-9
7. Al-Husinat LI, Jouryyeh B, Rawashdeh A, Robba C, Silva PL, Rocco PR, et al. The role of ultrasonography in the process of weaning from mechanical ventilation in critically ill patients. Diagnostics (Basel). 2024 Feb 12;14(4):398. https://doi.org/10.3390/diagnostics14040398
8. Abbas A, Embarak S, Walaa M, Lutfy SM. Role of diaphragmatic rapid shallow breathing index in predicting weaning outcome in patients with acute exacerbation of COPD. Int J Chron Obstruct Pulmon Dis. 2018 May 21:1655–61. https://doi.org/10.2147/COPD.S161691
9. Li S, Chen Z, Yan W. Application of bedside ultrasound in predicting the outcome of weaning from mechanical ventilation in elderly patients. BMC Pulm Med. 2021 Dec;21:1–9. https://doi.org/10.1186/s12890-021-01605-4
10. Li R, Zhou Y, Chen W, Lyu L, Qiu G, Pan C, et al. Speckle tracking ultrasound as a new tool to predict the weaning outcome of mechanical ventilation patients: a prospective observational study. Front Med (Lausanne). 2024 Dec 6;11:1449938. https://doi.org/10.3389/fmed.2024.1449938
11. da Silva RB, Neves VR, Montarroyos UR, Silveira MS, Sobral Filho DC. Heart rate variability as a predictor of mechanical ventilation weaning outcomes. Heart Lung. 2023 May 1;59:33–6. https://doi.org/10.1016/j.hrtlng.2023.01.007
12. Dong Z, Liu Y, Gai Y, Meng P, Lin H, Zhao Y, et al. Early rehabilitation relieves diaphragm dysfunction induced by prolonged mechanical ventilation: a randomised control study. BMC Pulm Med. 2021 Dec;21:1–8. https://doi.org/10.1186/s12890-021-01461-2
13. Pan L, Zhao J, Wang X, Huang L, Li S, Sun S. Value of diaphragmatic ultrasound parameters in assessing weaning outcomes and survival in ventilator-dependent intensive care unit patients. Am J Transl Res. 2024 Dec 15;16(12):7830. https://doi.org/10.62347/FDPE7053
14. Eltrabili HH, Hasanin AM, Soliman MS, Lotfy AM, Hamimy WI, Mukhtar AM. Evaluation of diaphragmatic ultrasound indices as predictors of successful liberation from mechanical ventilation in subjects with abdominal sepsis. Respir Care. 2019 May;64(5):564–9. https://doi.org/10.4187/respcare.06391
15. Farghaly S, Hasan AA. Diaphragm ultrasound as a new method to predict extubation outcome in mechanically ventilated patients. Aust Crit Care. 2017 Jan 1;30(1):37–43. https://doi.org/10.1016/j.aucc.2016.03.004
16. Pham T, Heunks L, Bellani G, Madotto F, Aragao I, Beduneau G, et al. Weaning from mechanical ventilation in intensive care units across 50 countries (WEAN SAFE): a multicentre, prospective, observational cohort study. Lancet Respir Med. 2023 May;11(5):465–76. https://doi.org/10.1016/S2213-2600(23)00089-9

17. Cohen G, Bergman I, Atamna A, Elis A. Predictive factors for successful weaning from mechanical ventilation in the internal medicine department. Intern Emerg Med. 2025 Feb 5:1–6. https://doi.org/10.1007/s11739-025-03860-3
18. Bonnici DM, Sanctuary T, Warren A, Murphy PB, Steier J, Marino P, et al. Prospective observational cohort study of patients with weaning failure admitted to a specialist weaning, rehabilitation and home mechanical ventilation centre. BMJ Open. 2016 Mar 1;6(3):e010025. https://doi.org/10.1136/bmjopen-2015-010025
19. Lin FC, Kuo YW, Jerng JS, Wu HD. Association of weaning preparedness with extubation outcome of mechanically ventilated patients in medical intensive care units: a retrospective analysis. PeerJ. 2020 Apr 13;8:e8973. https://doi.org/10.7717/peerj.8973
20. Vieira S, Teixeira C, Nasi L, Oliveira R, Trevisan C, Savi A, et al. Predicting success in weaning from mechanical ventilation: preliminary results from a multicentric study. Crit Care. 2005 Mar;9:1. https://doi.org/10.1186/cc3189
21. Lee HW, Cho YJ. The impact of mechanical ventilation duration on the readmission to intensive care unit: a population-based observational study. Tuberc Respir Dis (Seoul). 2020 Aug 21;83(4):303. https://doi.org/10.4046/trd.2020.0024
22. Hayat A, Khan A, Khalil A, Asghar A. Diaphragmatic excursion: does it predict successful weaning from mechanical ventilation. J Coll Physicians Surg Pak. 2017 Dec 1;27(12):743–6.
23. Swamy AH, Kumararadhya GB, Shivaramu D, Challakere GL, Chaitanya KU. Rapid shallow breathing index and ultrasonographic diaphragmatic parameters as predictors of weaning outcome in critically ill patients on mechanical ventilation. Ann Afr Med. 2025 Jan 1;24(1):79–85. https://doi.org/10.4103/aam.aam_45_24
24. Fradkin M, Elyashiv M, Camel A, Agay N, Brik M, Singer P, et al. A historical cohort study on predictors for successful weaning from prolonged mechanical ventilation and up to 3-year survival follow-up in a rehabilitation center. Respir Med. 2024 Jun 1;227:107636. https://doi.org/10.1016/j.rmed.2024.107636
25. Ma JG, Zhu B, Jiang L, Jiang Q, Xi XM. Gender- and age-based differences in outcomes of mechanically ventilated ICU patients: a Chinese multicentre retrospective study. BMC Anesthesiol. 2022;22:1. https://doi.org/10.1186/s12871-021-01555-8