



Clinical Critical Care

E-ISSN 2774-0048

VOLUME 34 NUMBER 1
JANUARY-DECEMBER 2026

Editor-in-Chief :
Suthat Rungruanghiranya

Ventilator-dependent unit as a specialized weaning unit in a resource-limited setting: Evidence review, implementation framework and clinical outcome

Rathasart Pengpu¹, Atikun Limsukon¹, Juthamas Inchai¹, Tula Wongpalee², Konlawij Trongtrakul¹

¹Division of Pulmonary, Critical Care and Allergy, Department of Internal Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand, 50200;

²Ventilator Dependent Unit, Department of Internal Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand, 50200

OPEN ACCESS



Citation:

Pengpu R, Limsukon A, Inchai J, Wongpalee T, Trongtrakul K. Ventilator-dependent unit as a specialized weaning unit in a resource-limited setting: evidence review, implementation framework and clinical outcome. Clin Crit Care 2026; 34: e260028.

Received: April 2, 2026

Revised: July 12, 2026

Accepted: August 28, 2026

Copyright:

© 2026 The Thai Society of Critical Care Medicine. This is an open-access article distributed under the terms of [Creative Commons Attribution-NonCommercial License \(CC BY-NC 4.0\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Data Availability Statement:

The data and code were available upon reasonable request (Konlawij Trongtrakul, email address: konlawij.tr@cmu.ac.th)

Funding:

This work received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing interests:

All authors have no conflicts of interest to declare.

Corresponding author:

Konlawij Trongtrakul
Division of Pulmonary, Critical Care and Allergy, Department of Internal Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand, 50200
E-mail: konlawij.tr@cmu.ac.th

ABSTRACT:

Background: Prolonged mechanical ventilation (PMV) creates substantial clinical and intensive care unit (ICU) burdens. Specialized weaning units (SWUs) provide multidisciplinary ventilator liberation and rehabilitation, but practical guidance and outcome data from resource-limited settings are limited.

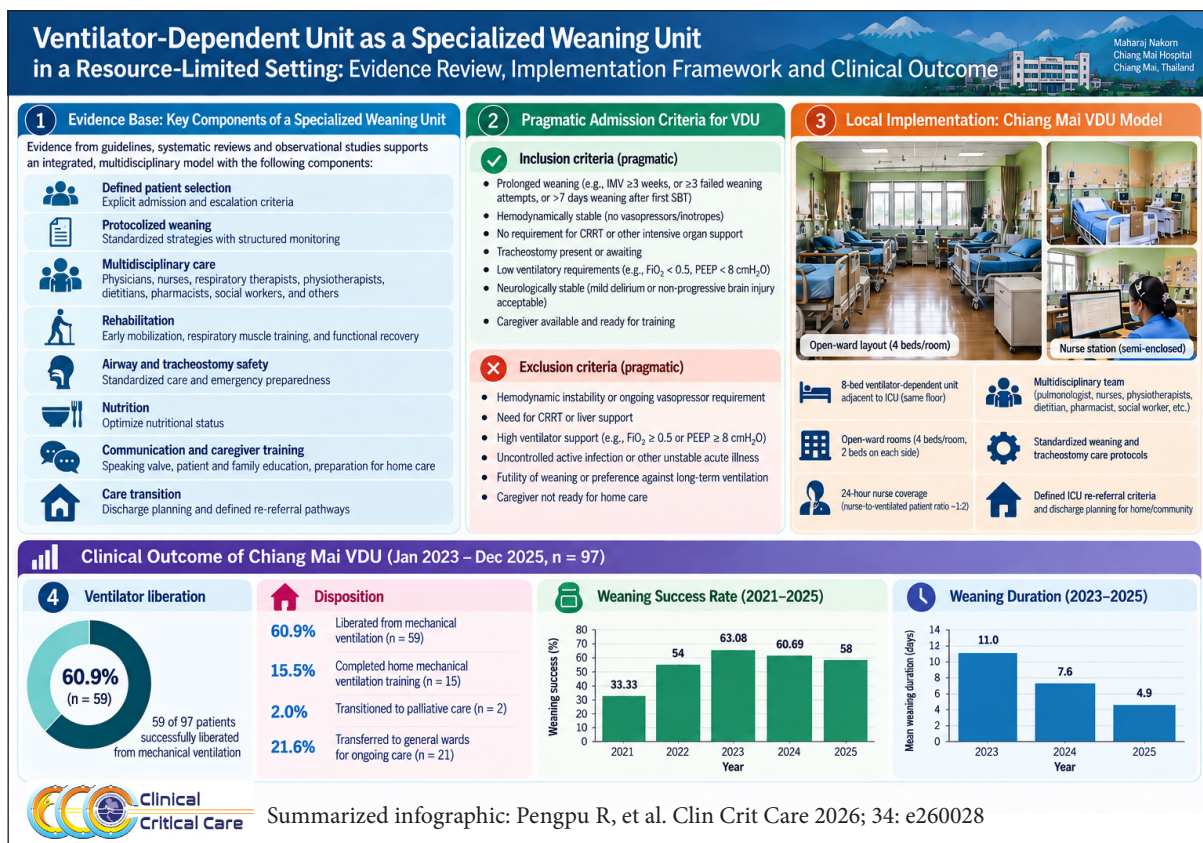
Objective: To synthesize evidence on the organization and clinical management of SWUs, describe implementation of a ventilator-dependent unit (VDU) adapted to a resource-limited tertiary hospital, and report a clinical evaluation.

Methods: A structured narrative review was conducted in PubMed for publications from January 2000 to December 2025 using terms related to PMV, difficult weaning, SWUs, VDU, rehabilitation, and models of care. Guidelines, consensus statements, systematic reviews, randomized trials, observational studies, and key implementation reports were narratively synthesized.

Results: Evidence supports geographically defined units, explicit admission and escalation criteria, protocolized weaning, multidisciplinary rehabilitation, airway and tracheostomy safety, nutrition, communication support, caregiver training, and early discharge planning. Our center establishes VDU according to these principles through ICU-adjacent open wards, 24-hour nurse coverage, shared allied-health services, and defined re-referral pathways. Among 97 VDU admissions, 60.9% were liberated from mechanical ventilation and in-unit mortality was 1.0%.

Conclusion: A structured SWU framework can be pragmatically adapted to a resource-limited tertiary hospital. The VDU was feasible and had acceptable safety outcomes; prospective multicenter studies are needed to establish effectiveness and cost-effectiveness.

Keywords: Critical care; Mechanical ventilation; Patient transfer; Respiratory insufficiency; Ventilator weaning; Ventilators



INTRODUCTION

Advances in critical care have increased survival after severe acute illness but have also increased the number of patients requiring prolonged mechanical ventilation (PMV). PMV is associated with extended ICU exposure, high use of critical care resources, impaired physical and cognitive recovery, and considerable patient and caregiver burden [1-4]. PMV has traditionally been defined as mechanical ventilation for at least 6 hours per day for 21 consecutive days; however, a 14-day threshold is increasingly used to identify patients with prolonged or difficult weaning earlier in their clinical trajectory [5,6].

Specialized weaning units (SWUs) were developed to provide structured, multidisciplinary care for patients who no longer need full ICU-level organ support but remain dependent on invasive or other advanced respiratory support. Reported objectives include ventilator liberation, rehabilitation, safe transition to long-term ventilation where needed, and improved availability of ICU beds for patients with acute organ failure [2,7,8]. The literature, however, is heterogeneous in definitions, organization, staffing, selection criteria, and outcomes. Many established models also depend on resources that are not universally available.

This article has three objectives: first, to present a structured narrative review of the evidence and practice recommendations relevant to SWUs; second, to translate this evidence into a practical implementation framework for a resource-limited setting; and third, to report the clinical evaluation of a Specialized Weaning Unit established in Thailand under the name Ventilator-Dependent Unit (VDU).

KEY MESSAGES:

- The evidence review identifies the essential components of a specialized weaning unit: defined patient selection, multidisciplinary care, protocolized weaning, rehabilitation, safety and escalation systems, and coordinated care transition.
- The Chiang Mai VDU operationalized these components through an 8-bed ICU-adjacent model using shared allied-health personnel and explicit ICU re-referral criteria.
- The VDU was feasible and had acceptable safety outcomes; prospective multicenter studies are needed to establish effectiveness and cost-effectiveness.

MATERIALS AND METHODS

Structured narrative review

Review question and scope

We conducted a structured narrative review to identify evidence and recommendations on the establishment, organization, clinical management, safety, rehabilitation, and transition-of-care functions of SWUs for adults with PMV or difficult weaning. The review was designed to inform a practical implementation framework rather than to estimate a pooled treatment effect. It therefore did not include meta-analysis or formal risk-of-bias grading.

Information sources and search strategy

We searched PubMed for English-language publications from January 1, 2000, to December 31, 2025. Search terms were combined using Boolean operators and included: “prolonged mechanical ventilation,” “ventilator dependent,” “specialized weaning unit,” “special weaning unit,” “ventilator dependent unit,” “weaning unit,” “difficult weaning,” “ventilator weaning,” “rehabilitation,” “tracheostomy,” and “model of care”.

The search was supplemented by screening reference lists of key guidelines, consensus statements, systematic reviews, and major observational studies. We also reviewed international guidance relevant to prolonged weaning and critical care organization, including the British Thoracic Society/Intensive Care Society model of care for specialized weaning units, ATS/ACCP liberation-from-mechanical-ventilation guidance, AARC spontaneous breathing trial guidance, and critical care service standards [8-12].

Eligibility and selection

Eligible sources were international clinical practice guidelines, consensus statements, systematic reviews, randomized controlled trials, prospective or retrospective observational studies, service evaluations, and key implementation reports that addressed at least one of the following domains: PMV definition; patient selection; physical infrastructure; staffing or multidisciplinary team composition; ventilator weaning; tracheostomy management; rehabilitation; nutrition; communication and swallowing; psychological or palliative care; safety monitoring; discharge planning; home mechanical ventilation; clinical outcomes; or health-system integration.

We excluded pediatric studies, studies focused exclusively on acute extubation without relevance to prolonged or difficult weaning, reports without sufficient methodological or operational information, duplicate publications, and non-English publications when an English full text or detailed English abstract was unavailable.

Titles and abstracts were screened for relevance. Full texts of potentially relevant sources were reviewed and categorized by evidence type and implementation domain. Because the purpose was a structured narrative synthesis, evidence was integrated qualitatively, with priority given to guideline recommendations and higher-level evidence where available. Study findings were interpreted in the context of population differences, PMV definitions, service model, and healthcare setting.

Data charting and synthesis

For each included source, we charted the country or healthcare setting, design, patient population, PMV or weaning definition, care model, unit characteristics, staffing, clinical processes, outcomes, limitations, and implementation implications. Findings were synthesized into six operational domains: (1) patient selection and admission; (2) multidisciplinary workforce; (3) infrastructure and equipment; (4) clinical weaning and rehabilitation pathways; (5) safety and escalation; and (6) discharge planning and health-system integration.

The resulting framework was then compared with the operational features of the VDU at Chiang Mai University to identify which elements could be implemented directly and which required local adaptation.

Evidence reviews and practical framework

Why specialized weaning units are needed

Patients with PMV frequently have respiratory muscle weakness, secretion burden, tracheostomy-related needs, malnutrition, neuromuscular dysfunction, delirium, anxiety, impaired communication, and prolonged functional dependence. These needs extend beyond the immediate stabilization role of an ICU. SWUs create a focused setting for gradual ventilator liberation and rehabilitation after resolution of acute instability [5,8,13].

Published SWU populations and outcomes vary substantially. Reported successful weaning rates range from approximately 39% to 75%, reflecting differences in patient case mix, thresholds for transfer, definitions of weaning success, access to long-term ventilation, and local health systems [2,6,14-17]. Consequently, a unit should monitor its own case mix and outcomes rather than apply external benchmarks uncritically.

Patient selection and admission

The central principle is transfer after the acute phase of critical illness has stabilized, not transfer based solely on the number of ventilator days. A pragmatic eligibility checklist includes prolonged or difficult weaning, low and stable ventilatory requirements, hemodynamic stability without vasopressors or inotropes, no requirement for continuous renal replacement therapy or other acute organ support, a stable neurologic condition, a manageable airway plan, potential to participate in rehabilitation, and treatment goals compatible with ongoing active care [5,8] (Table 1).

Common exclusion criteria are unstable shock, escalating oxygen or positive end-expiratory pressure requirements, active major bleeding, uncontrolled sepsis, rapidly progressive neurologic illness, need for extracorporeal membrane oxygenation or continuous renal replacement therapy, or a requirement for ICU-level organ support. These criteria should be paired with explicit re-referral procedures because some patients deteriorate after transfer [8,18,19] (Table 2).

Multidisciplinary workforce

The SWU model depends on coordinated multidisciplinary care. Physicians lead eligibility assessment, complex ventilatory strategy, airway decisions, medical review, and goals-of-care discussions. Nurses provide continuous ventilator and tracheostomy surveillance, secretion care, delirium prevention, mobilization support, patient communication, and caregiver preparation [8,9,20]. Respiratory physiotherapy supports secretion clearance, respiratory muscle conditioning, mobilization, and progression of spontaneous breathing [21,22]. Occupational therapy addresses function and activities of daily living; dietetic input supports recovery from catabolism and muscle loss; pharmacy improves medication safety and sedation/de-prescribing review; speech and language therapy supports communication, swallowing, speaking-valve use, and decannulation; and psychology and palliative care support symptoms, distress, communication, and values-based care [23-29] (Table 3).

Table 1. Suggested admission checklist for transfer to a specialized weaning unit.

Domain	Suggested criteria
Prolonged/difficult weaning	Invasive mechanical ventilation for ≥ 14 days, or prolonged/difficult weaning
Weaning difficulty	≥ 3 failed weaning attempts or >7 days of weaning after the first spontaneous breathing trial
Hemodynamic status	No vasopressor or inotropic support; clinically stable circulation
Other organ support	No continuous renal replacement therapy or other acute ICU-level organ support
Respiratory status	Stable or decreasing oxygen and PEEP requirements; no rapidly escalating ventilatory support
Airway	Tracheostomy, or planned/anticipated if clinically appropriate
Neurologic condition	Stable condition; mild delirium or non-progressive brain injury may be acceptable if rehabilitation participation is possible
Rehabilitation potential	Ability or reasonable potential to participate in multidisciplinary rehabilitation
Goals of care	Ongoing active treatment aligned with patient values; no medical futility identified

Abbreviation: PEEP: Positive end-expiratory pressure. Adapted from MacIntyre et al [5] and the BTS/ICS model of care for specialized weaning units [8].

Table 2. Suggested exclusion criteria for specialized weaning unit admission.

Domain	Exclusion criterion
Hemodynamic	Ongoing vasopressor/inotropic support or unstable shock
Organ support	Continuous renal replacement therapy, extracorporeal membrane oxygenation, or other ICU-level acute organ support
Respiratory	Escalating ventilator support or persistently high oxygen requirement
Neurologic	Unstable neurological condition or uncontrolled seizures
Acute medical condition	Active sepsis, major bleeding, or another condition requiring ICU-level care
Goals of care	Comfort-focused care alone, unless the unit has a designated palliative-care function; medical futility

Adapted from MacIntyre et al [5] and the BTS/ICS model of care for specialized weaning units [8].

Table 3. Core multidisciplinary team functions in a specialized weaning unit.

Discipline	Core contribution
Physician	Admission decisions, daily medical review, ventilator strategy, complex airway issues, escalation and discharge planning
Registered nurse	24-hour monitoring, tracheostomy care, secretion management, deterioration recognition, communication and caregiver education
Physiotherapist	Respiratory rehabilitation, airway clearance, mobilization, exercise progression and assistance with weaning
Dietitian	Individualized calorie/protein strategy, feeding tolerance management and longitudinal nutrition reassessment
Occupational therapist	Activities-of-daily-living training, upper-limb function, transfers, adaptive equipment and discharge planning
Pharmacist	Medication reconciliation, antimicrobial stewardship, sedation/delirium review and medication safety
Speech and language therapist	Communication, swallowing, speaking-valve assessment, oral intake and decannulation support
Psychologist	Assessment and management of anxiety, depression, trauma-related symptoms, sleep and cognitive distress
Palliative-care specialist	Symptom control, goals-of-care communication, caregiver support and anticipatory planning

Compiled from published guidance and supporting literature [8, 9, 20-29].

Ideal staffing ratios may be unattainable in resource-limited hospitals. The essential requirement is not identical staffing numbers but reliable access to relevant skills, role clarity, training, communication, and governance. Task-sharing should be used only within defined competencies and with appropriate supervision [8,9].

Infrastructure and equipment

A SWU should be a geographically defined area, preferably near the ICU to facilitate timely escalation. Essential design features include adequate bed space for emergency airway access and rehabilitation, visual observation, continuous or intermittent monitoring appropriate to patient acuity, bedside suction, emergency airway equipment, spare tracheostomy tubes, ventilators that support spontaneous breathing modes, infusion and enteral feeding pumps, transfer aids, and basic rehabilitation equipment [5,8,9,30,31].

Infection prevention requires hand-hygiene access, environmental cleaning, safe equipment handling, and the capacity to isolate or cohort patients according to infection risk. Where single isolation rooms are unavailable, hospitals should establish area-based measures, occupancy restrictions, and escalation procedures in collaboration with infection-prevention teams [8,9].

Clinical weaning and rehabilitation pathway

A protocolized but individualized pathway should begin with a structured reassessment of factors that impede ventilator liberation: respiratory mechanics, gas exchange, airway patency, secretion load, cardiovascular function, respiratory and peripheral muscle weakness, nutrition, sleep, delirium, neurologic status, communication barriers, and patient goals. Daily readiness screening and spontaneous breathing trials should be used when appropriate, with prompt correction of reversible contributors after failure [11,32–34].

Rehabilitation should be coordinated with respiratory care and include secretion clearance, respiratory muscle training where appropriate, progressive mobilization,

strengthening, transfer training, activities-of-daily-living practice, communication and swallowing support, and nutrition optimization [13,21–25,35,36]. The ABCDEF bundle offers a practical structure for pain assessment, awakening and breathing trials, sedation choice, delirium prevention and management, early mobility, and family engagement [34,35] (Table 4).

Safety, escalation, discharge planning, and care transition

Safety requires a clear transfer plan, documented treatment goals, airway contingency planning, trained staff, standard operating procedures, an audit of adverse events, and a defined route for urgent ICU review. Airway emergencies, refractory respiratory failure, acute hemodynamic instability, neurological deterioration, and rapidly progressive sepsis should trigger urgent escalation [8,11,19].

Discharge planning begins at admission. Patients may proceed to ventilator liberation and rehabilitation, nocturnal noninvasive ventilation, long-term tracheostomy ventilation, or palliative care. For home mechanical ventilation, caregivers require practical training in tracheostomy care, suctioning, ventilator management, alarm response, emergency planning, consumables, backup power, and access to ongoing clinical support [8,19,37].

Local implementation: The Chiang Mai ventilator-dependent unit

Unit setting

The VDU at the Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand, was established in 2016 to provide organized care for patients requiring prolonged ventilatory support. Following temporary suspension during the coronavirus disease 2019 pandemic, the unit resumed in 2021 as a multidisciplinary service based on SWU principles.

Table 4. Core components of the specialized weaning unit care pathway.

Component	Practical actions
Early referral	Standard referral pathway for difficult or prolonged weaning; documented transfer and escalation plan
Admission assessment	Multidisciplinary review of ventilator trajectory, airway, organ stability, nutrition, function, cognition and goals of care
Weaning	Daily readiness screening; spontaneous breathing trials; individualized gradual weaning when required
Tracheostomy care	Cuff-deflation assessment, secretion management, speaking-valve trials, decannulation criteria and emergency equipment
Rehabilitation	Respiratory therapy, mobilization, strength and ADL training, nutrition, communication and swallowing support
Delirium and psychological care	ABCDEF-based preventive practices, sleep promotion, communication support and targeted psychological input
Safety	Monitoring, safety briefing, adverse-event review, infection prevention and explicit ICU escalation criteria
Discharge planning	Early caregiver assessment, equipment planning, training, written emergency plan, follow-up and community linkage

Abbreviation: ADL: Activities of daily living. Adapted from the BTS/ICS model of care for specialized weaning units and liberation-from-mechanical-ventilation guidance [8, 11].

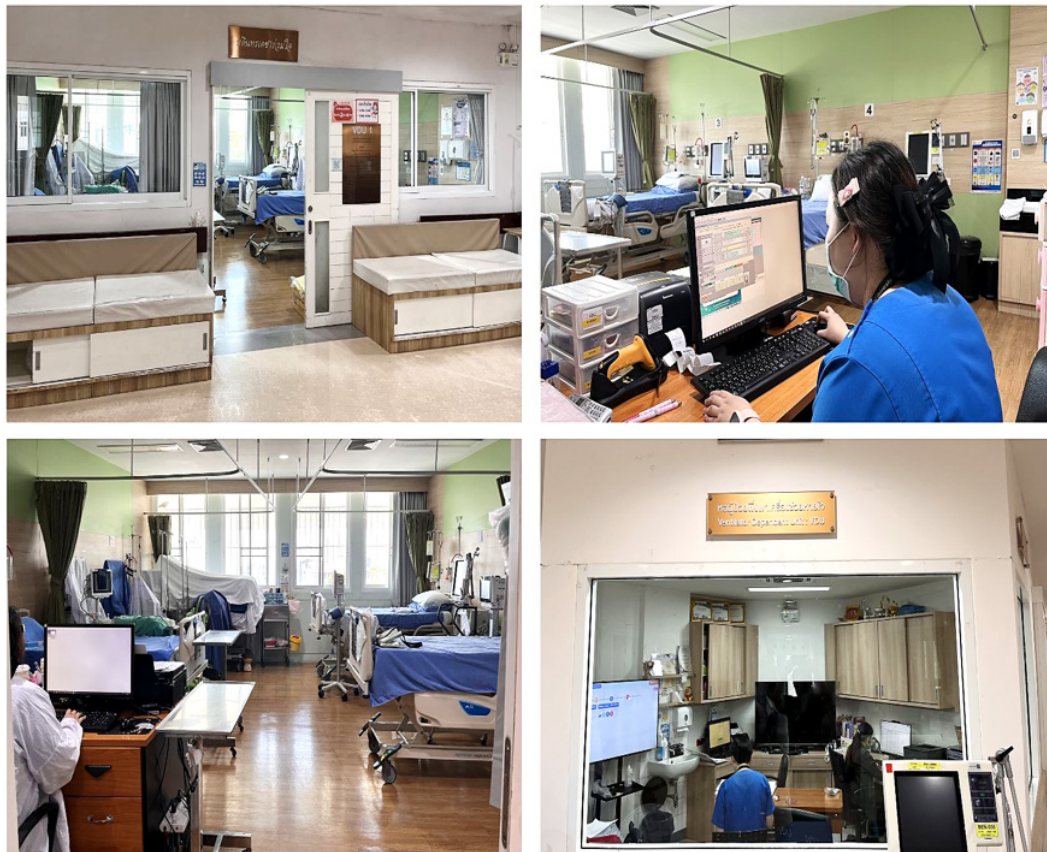


Figure 1. The upper images (left and right) illustrate the open-ward layout, with each large room accommodating four patient beds (two beds on each side). The lower left image demonstrates the isolation approach for patients with multidrug-resistant organisms, using curtain partitioning and, where necessary, reducing bed occupancy to a single bed to minimize transmission risk. The lower right image shows a dedicated nurse station, designed as a semi-enclosed workspace that can also function as a small meeting area, while maintaining direct visual oversight of both open-ward rooms.



Figure 2. The image illustrates essential clinical equipment, including ventilators, airway management devices, and standard patient monitoring systems. The wider than standard inter-bed spacing supports comprehensive rehabilitation by enabling safe mobilization, physiotherapy, and multidisciplinary care.

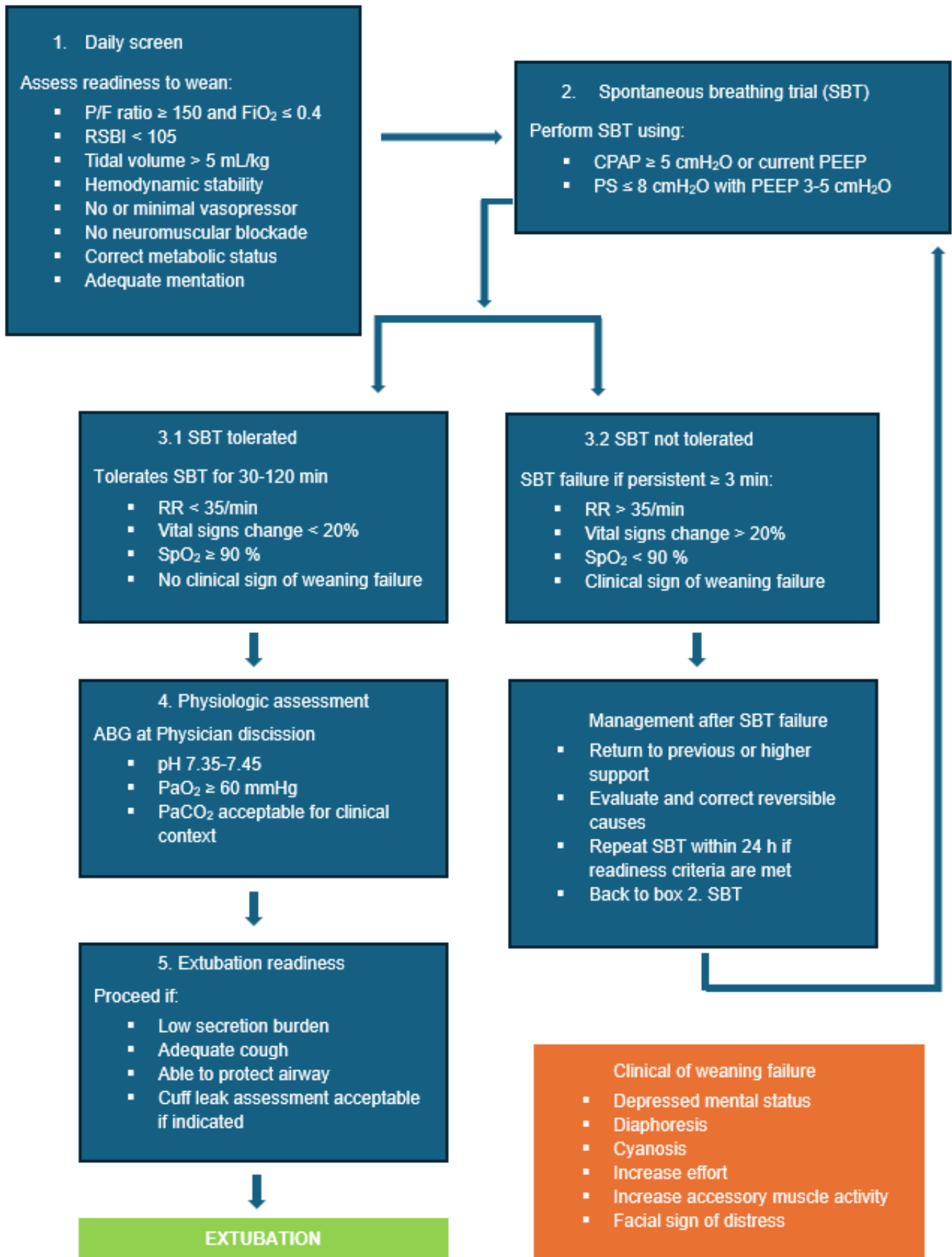


Figure 3. Proposed spontaneous breathing trial protocol for patients undergoing prolonged mechanical ventilation in a specialized weaning unit. Patients are screened daily for readiness to wean. Eligible patients undergo a spontaneous breathing trial using CPAP or low-pressure support. Patients who successfully tolerate SBT proceed to extubation assessment, whereas patients who fail SBT receive optimization of reversible causes before repeat assessment.

Abbreviations: SBT: Spontaneous breathing trial; RSBI: Rapid shallow breathing index; P/F ratio: $\text{PaO}_2/\text{FiO}_2$ ratio; PS: Pressure support; PEEP: Positive end-expiratory pressure; RR: Respiratory rate; VT: Tidal volume.



Figure 4. The upper images (left and right) illustrate post-discharge follow-up and continuity of care delivered via telemedicine, involving both patients and their caregivers. The lower left image demonstrates coordinated follow-up care in collaboration with the Department of Family Medicine. The lower right image highlights integration with community services to support ongoing home-based care.

The VDU is located on the same floor as the medical ICU and comprises eight beds in two open wards, with four beds per room. Inter-bed spacing exceeds 100 cm, allowing space for ventilators, airway emergencies, physiotherapy, early mobilization, and bedside rehabilitation. A dedicated nurse station provides direct visual oversight. Dedicated isolation rooms are not currently available; patients with multidrug-resistant organisms are managed using area-based isolation, curtain partitioning, and reduced bed occupancy when necessary, as illustrated in Figure 1 and 2.

Admission and staffing model

The VDU accepts patients after the acute ICU phase has resolved who are hemodynamically and respiratory stable and do not require intensive support for other organ systems. Patients are pragmatically grouped as: (1) prolonged weaning; (2) recovery from acute illness with ongoing partial respiratory support, including noninvasive ventilation or high-flow nasal cannula; and (3) end-of-life care requiring specialist symptom and care-transition support.

The unit is staffed by a pulmonologist/intensivist and an internal medicine resident providing daily consultant-led rounds. Registered nurses provide 24-hour coverage at an approximate ratio of 1:2 to 1:3, supported by nurse assistants at an approximate ratio of 1:4. Physiotherapy and occupational therapy are shared services, generally providing 1–2 hours per patient per day. Dietetic review occurs daily or several times per week, a pharmacist participates in clinical review, speech and language functions are partly shared by occupational therapists and physiotherapists, and palliative care is available by consultation. A dedicated clinical psychologist was not available during the study period.

Care processes and transition

Core VDU processes are individualized ventilator management, protocolized weaning, tracheostomy care, prevention of ventilator-associated pneumonia, central line-associated bloodstream infection, catheter-associated urinary tract infection, pressure injury and falls, rehabilitation, nutritional optimization, medication review, caregiver training, and discharge planning. A protocol for daily readiness to wean assessment has been implemented, as illustrated in Figure 3.

All patients are coordinated with the Department of Family Medicine for continuity after discharge, with additional outpatient and community support as appropriate in post-discharge care, as illustrated in Figure 4.

Clinical evaluation of the ventilator-dependent unit

The comparison illustrates how key elements of specialized weaning care were translated into practice within a resource-limited tertiary hospital. While several core components could be implemented directly, others required pragmatic adaptation according to local staffing, infrastructure, and resource availability as illustrated in Table 5.

VDU service outcomes

Following implementation of the fully multidisciplinary VDU model (2021–2025), descriptive service evaluation demonstrated favorable trends, with weaning success increasing from 33.3% in 2021 to 58.0% in 2025 and the mean weaning duration decreasing from 11.0 days in 2023 to 4.9 days in 2025 as illustrated in Figure 5. (Chiang Mai University Hospital VDU, unpublished data).

Between 2023-2025, 97 patients were admitted to the VDU, of whom 59 (60.9%) were successfully liberated from mechanical ventilation. Fifteen patients (15.5%) and caregivers completed structured home mechanical ventilation training, and two patients (2.0%) transitioned to palliative care. The remaining patients were transferred to general medical wards for ongoing rehabilitation or care.

Overall adverse events occurred in 13 patients (13.4%). One patient (1.0%) died in the unit, nine (9.3%) required ICU escalation, one of 59 liberated patients (1.7%) required reintubation within 48 hours, and one new pressure injury occurred (1.0%). During VDU admission, the hospital-acquired infection rate was 2.29 per 1,000 patient-days, ventilator-associated pneumonia was 1.37 per 1,000 ventilator-days, and catheter-associated urinary tract infection was 3.99 per 1,000 catheter-days. (Chiang Mai University VDU, unpublished data).

Table 5. Comparison of guideline-based specialized weaning unit elements and local VDU adaptation.

Component	Guideline-based SWU model	VDU implementation in Chiang Mai	Local adaptation
Unit location	Defined unit, preferably close to ICU	Eight-bed unit on same floor as medical ICU	ICU proximity retained
Physician leadership	Dedicated respiratory/ICU expertise	Pulmonologist/intensivist with internal medicine resident	Consultant-led shared model
Nursing	High-acuity nurse coverage	Nurse-to-patient ratio approximately 1:2 to 1:3, 24 hours/day	Core monitoring retained
Physiotherapy	Dedicated respiratory physiotherapy	Shared respiratory and rehabilitation physiotherapy	Role integration
Occupational therapy	Dedicated OT access	Shared OT, 1–2 hours/patient/day	Shared service
Dietetics/pharmacy	Regular specialist availability	Dietetic review and pharmacist participation	Shared service
Speech and language therapy	Dedicated assessment for communication/swallowing	Functions partly shared with OT/physiotherapy	Task-sharing with referral when available
Psychology	Dedicated or regular access	Not available during study period	Identified service gap
Infection prevention	Isolation capacity/cohorting	Area-based isolation and reduced occupancy for high-risk infection	Pragmatic infection-control strategy
Escalation	Immediate ICU re-referral pathway	Defined triggers and same-floor ICU access	Rapid escalation retained

Abbreviations: ICU: Intensive care unit; OT: Occupational therapy; SWU: Specialized weaning unit; VDU: Ventilator-dependent unit.

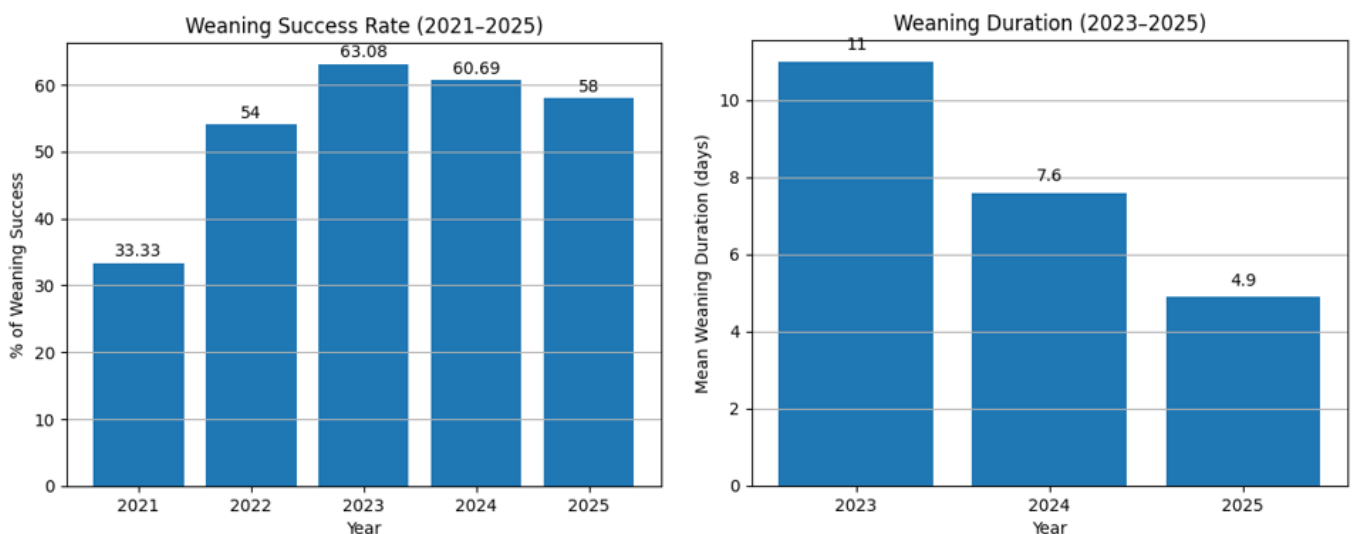


Figure 5. The left panel presents the annual rates of successful weaning from mechanical ventilation from 2021 to 2025. The right panel depicts the mean duration of weaning among successfully weaned patients between 2023 and 2025. (Chiang Mai University VDU, unpublished data)

DISCUSSION

This article integrates a structured narrative review, a practical implementation framework, and a clinical evaluation of an adapted SWU. The review indicates that a SWU requires more than a location for patients with prolonged ventilation. It requires systematic patient selection, a coordinated multidisciplinary team, ventilator and tracheostomy expertise, rehabilitation, nutrition, communication support, safety monitoring, explicit escalation pathways, and early planning for care transition [5,8,11].

The Chiang Mai VDU translated these components into an eight-bed, ICU-adjacent model using 24-hour nursing and shared allied-health personnel. This type of adaptation may be relevant to hospitals that cannot immediately establish the full staffing configuration described in high-resource guidelines. However, adaptation should not compromise safety; essential competencies, escalation procedures, infection-control measures, and clinical governance must remain in place [8,9].

The observed VDU liberation rate of 60.9%, ICU escalation rate of 9.3%, and in-unit mortality of 1.0% are consistent with operational feasibility and acceptable safety in this setting. They are not controlled effectiveness estimates. The clinical value of a VDU may include outcomes that were not assessed here, such as functional recovery, communication, caregiver competence, quality of life, discharge destination, long-term ventilation dependence, and cost-effectiveness [2,7,19,30,31].

Limitations

The review was structured but narrative, used PubMed as the primary database, was limited to English-language sources, and did not undertake formal risk-of-bias assessment or meta-analysis. It should therefore be considered an implementation-focused evidence synthesis rather than a systematic review.

The number of VDU transfers was modest, limiting precision and subgroup analysis. Outcomes after hospital discharge, health-related quality of life, functional status, caregiver outcomes, and costs were unavailable. Finally, descriptive service outcomes cannot establish causal effectiveness.

CONCLUSION

A structured review supports an SWU model centered on patient selection, multidisciplinary weaning and rehabilitation, safety systems, and care transition. The Chiang Mai VDU demonstrates how these principles can be adapted to an ICU-adjacent, resource-limited tertiary-hospital setting. Prospective multicenter studies should evaluate effectiveness, costs, long-term patient-centered outcomes, and equitable access.

Acknowledgement: The authors thank the Ventilator-Dependent Unit team for their clinical care, collaboration, and support of this work. The authors gratefully acknowledge the hospital staff, patients, and their families who provided written informed consent for the publication of the photographs included in this review.

CRedit Author Contributions: R.P.: Conceptualization, Writing – Original Draft, Writing – Review & Editing and Visualization; A.L., J.I., T.W.: Resources and Writing – Review & Editing; K.T.: Conceptualization, Writing – Review & Editing, and Supervision; All authors have read and approved the final version of the manuscript and agree to be accountable for their individual contributions.

Generative AI Statement: A generative artificial intelligence tool (ChatGPT, OpenAI) was used as an assistive tool for language editing and manuscript organization during the preparation and revision of this manuscript. It was not used to generate, analyze, or interpret study data and was not listed as an author. All authors reviewed and verified the accuracy, originality, integrity, and final content of the manuscript and take full responsibility for the published work.

REFERENCES

1. Wozniak HA-O, Beckmann TS, Dos Santos Rocha A, Pugin J, Heidegger CP, Cereghetti S. Long-stay ICU patients with frailty: mortality and recovery outcomes at 6 months. *Ann Intensive Care*. 2024;14. doi:https://doi.org/10.1186/s13613-024-01261-x.
2. Lone NI, Walsh TS. Prolonged mechanical ventilation in critically ill patients: epidemiology, outcomes and modelling the potential cost consequences of establishing a regional weaning unit. *Crit Care Med*. 2011. doi:https://doi.org/10.1186/cc10117.
3. Kahn JM, Le T, Angus DC, Cox CE, Hough CL, White DB, et al. The epidemiology of chronic critical illness in the United States*. *Crit Care Med*. 2015;43:282-7. doi: https://doi.org/10.1097/CCM.0000000000000710.
4. Kahn JM, Davis BS, Le TQ, Yabes JG, Chang C-CH, Angus DC. Variation in mortality rates after admission to long-term acute care hospitals for ventilator weaning. *Journal of Critical Care*. 2018;46:6-12. doi:https://doi.org/10.1016/j.jcrc.2018.03.022.
5. MacIntyre NR, Epstein Sk Fau - Carson S, Carson S Fau - Scheinhorn D, Scheinhorn D Fau - Christopher K, Christopher K Fau - Muldoon S, Muldoon S. Management of patients requiring prolonged mechanical ventilation: report of a NAMDRG consensus conference. *Chest*. 2005;128:3937-54. doi:https://doi.org/10.1378/chest.128.6.3937.
6. Amir B, Mai OA-OX, Shira T, Ido PA-O, Nave P, Carmi BA-O. Predictors of weaning success in patients on prolonged mechanical ventilation: a retrospective cohort study. *J Clin Med*. 2025. doi: https://doi.org/10.3390/jcm14134427.
7. Finnerty J, Gill SE, Alcock E, Johnson E, Flowers E, Price J, et al. Retrospective service evaluation of a specialist weaning unit. *Journal of the Intensive Care Society*. 2024;25:350-2. doi: https://doi.org/10.1177/17511437241257117.
8. Society BT. BTS/ICS model of care for specialised weaning units british thoracic society reports, Vol 14, Issue 1, 2023;14.
9. Intensive Care Society. Guidelines for the Provision of Intensive Care Services (GPICS). London: ICS; latest edition. Intensive Care Society. 2022;version 2.1.
10. Fan E, Zakhary B, Amaral A, McCannon J, Girard TD, Morris PE, et al. Liberation from mechanical ventilation in critically ill adults. An official ATS/ACCP clinical practice guideline. *Ann Am Thorac Soc*. 2017;14(3):441-3. doi: https://doi.org/10.1513/AnnalsATS.201612-993CME.
11. Roberts KJ, Goodfellow LT, Battey-Muse CM, Hoerr CA, Carreon ML, Sorg ME, et al. AARC clinical practice guideline: spontaneous breathing trials for liberation from adult mechanical ventilation. *Respir Care*. 2024;69:891-901. doi:https://doi.org/10.4187/respcare.11735.
12. Girard Td Fau - Alhazzani W, Alhazzani W Fau - Kress JP, Kress Jp Fau - Ouellette DR, Ouellette Dr Fau - Schmidt GA, Schmidt Ga Fau - Truitt JD, Truitt Jd Fau - Burns SM, et al. An official American thoracic society/American college of chest physicians clinical practice guideline: liberation from mechanical ventilation in critically ill adults. Rehabilitation protocols, ventilator liberation protocols, and cuff leak tests. *Am J Respir Crit Care Med*. 2017; 195:120-33. doi: https://doi.org/10.1164/rccm.201610-2075ST.
13. Ambrosino N, Vitacca M. The patient needing prolonged mechanical ventilation: a narrative review. *Multidiscip Respir Med*. 2018; 13. doi:https://doi.org/10.1186/s40248-018-0118-7.
14. Blackwood B, Alderdice F, Burns K, Cardwell C, Lavery G, O'Halloran P. Use of weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: Cochrane systematic review and meta-analysis. *BMJ*. 2011;342:c7237. doi: https://doi.org/10.1136/bmj.c7237.

15. Huang CA-O. The survival outcomes of patients requiring prolonged mechanical ventilation. *Medicina* (Kaunas). 2023. doi: <https://doi.org/10.3390/medicina59030614>.
16. Paul N, Ribet Buse E, Grunow JJ, Schaller SJ, Spies CD, Edel A, et al. Prolonged mechanical ventilation in critically ill patients: six-month mortality, care pathways, and quality of life. *Chest*. 2025. doi: <https://doi.org/10.1016/j.chest.2025.01.018>.
17. Lee JM, Lee SM, Song JH, Kim YS. Clinical outcomes of difficult-to-wean patients with ventilator dependency at intensive care unit discharge. *Acute Crit Care*. 2020. doi: <https://doi.org/10.4266/acc.2020.00199>.
18. Davidson AC, Banham S, Elliott M, Kennedy D, Gelder C, Glossop A, et al. BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. *Thorax*. 2016; 71. doi: <https://doi.org/10.1136/thoraxjnl-2015-208209>.
19. Pilcher DV, Bailey MJ Fau - Treacher DF, Treacher Df Fau - Hamid S, Hamid S Fau - Williams AJ, Williams Aj Fau - Davidson AC, Davidson AC. Outcomes, cost and long term survival of patients referred to a regional weaning centre. *Thorax*. 2005; 60:187-92. doi: <https://doi.org/10.1136/thx.2004.026500>.
20. Gunther I Fau - Pradhan D, Pradhan D Fau - Lubinsky A, Lubinsky A Fau - Urquhart A, Urquhart A Fau - Thompson JA, Thompson Ja Fau - Reynolds S, Reynolds S. Use of a multidisciplinary mechanical ventilation weaning protocol to improve patient outcomes and empower staff in a medical intensive care unit. *Dimens Crit Care Nurs*. 2021;01:67-74. doi: <https://doi.org/10.1097>.
21. Schweickert WD, Pohlman Mc Fau - Pohlman AS, Pohlman As Fau - Nigos C, Nigos C Fau - Pawlik AJ, Pawlik Aj Fau - Esbrook CL, Esbrook Cl Fau - Spears L, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. *Lancet* 2009;373:1874-82. doi: [https://doi.org/10.1016/S0140-6736\(09\)60658-9](https://doi.org/10.1016/S0140-6736(09)60658-9).
22. Elkins M, Dentice R. Inspiratory muscle training facilitates weaning from mechanical ventilation among patients in the intensive care unit: a systematic review. *Journal of Physiotherapy*. 2015;61:125-34. doi: <https://doi.org/10.1016/j.jphys.2015.05.016>.
23. Lo S-C, Ma KS-K, Li Y-R, Li Z-Y, Lin C-H, Lin H-C, et al. Nutritional support for successful weaning in patients undergoing prolonged mechanical ventilation. *Scientific Reports*. 2022;12:12044. doi: <https://doi.org/10.1038/s41598-022-15917-w>.
24. Bakshi N KA, Ferozi S. Nutrition screening and assessment among critically ill patients. *Nutrition During Intensive Care*. *IntechOpen*. 2024. doi: <https://doi.org/10.5772/intechopen.1007337>.
25. Smith M, Tsai S, Peterson E. Occupational therapy interventions and early engagement for patients in intensive care: a systematic review. *Am J Occup Ther*. 2025;79. doi: <https://doi.org/10.5014/ajot.2025.050695>.
26. Rose L, Nonoyama M, Rezaie S, Fraser I. Psychological wellbeing, health related quality of life and memories of intensive care and a specialised weaning centre reported by survivors of prolonged mechanical ventilation. *Intensive and Critical Care Nursing*. 2014;30:145-51. doi: <https://doi.org/10.1016/j.iccn.2013.11.002>.
27. Khan M, Nishi SE. Mechanically ventilated patients experience stress and feelings of vulnerability. *Evid Based Nurs*. 2022;25:51. doi: <https://doi.org/10.1136/ebnurs-2020-103364>.
28. Hamadalneel YA-O, Ahmed HO. Impact of clinical pharmacist intervention in the intensive care unit, Wad Medani, Sudan: a cross-sectional, prospective study. *Integr Pharm Res Pract*. 2024;9:43-9. doi: <https://doi.org/10.2147/IPRPS459170>.
29. McGrath BA, Wallace S, Lynch J, Bonvento B, Coe B, Owen A, et al. Improving tracheostomy care in the United Kingdom: results of a guided quality improvement programme in 20 diverse hospitals. *British Journal of Anaesthesia*. 2020;125:e119-e29. doi: <https://doi.org/10.1016/j.bja.2020.04.064>.
30. Davies Mg Fau - Quinnell TG, Quinnell Tg Fau - Oscroft NS, Oscroft Ns Fau - Clutterbuck SP, Clutterbuck Sp Fau - Shneerson JM, Shneerson Jm Fau - Smith IE, Smith IE. Hospital outcomes and long-term survival after referral to a specialized weaning unit. 2017. doi: <https://doi.org/10.1093/bja/aex031>.
31. Mifsud Bonnici D, Sanctuary T, Warren AA-O, 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;6. doi: <https://doi.org/10.1136/bmjopen-2015-010025>.
32. Hirzallah FM, Alkaissi A, do Céu Barbieri-Figueiredo M. A systematic review of nurse-led weaning protocol for mechanically ventilated adult patients. *Nursing in Critical Care*. 2019;24:89-96. doi: <https://doi.org/10.1111/nicc.12404>.
33. Wang Y, Wang Y, Gu S, Zhu L, Jia R, Tan M, et al. Nurse-led weaning protocols-a systematic review and meta-analysis. *Front Med* 2025;12. doi: <https://doi.org/10.3389/fmed.2025.1514287>.
34. Sosnowski K, Lin F, Chaboyer W, Ranse K, Heffernan A, Mitchell M. The effect of the ABCDE/ABCDEF bundle on delirium, functional outcomes, and quality of life in critically ill patients: A systematic review and meta-analysis. *International Journal of Nursing Studies*. 2023;138:104410. doi: <https://doi.org/10.1016/j.ijnurstu.2022.104410>.
35. Marra A, Ely EW, Pandharipande PP, Patel MB. The ABCDEF bundle in critical care. *Crit Care Clin*. 2017;33:225-43. doi: <https://doi.org/10.1016/j.ccc.2016.12.005>.
36. Needham DM, Korupolu R. Rehabilitation quality improvement in an intensive care unit setting: implementation of a quality improvement model. *Top Stroke Rehabil*. 2010;17:271-81. doi: <https://doi.org/10.1310/tsr1704-271>.
37. Toussaint MA-O, Wijkstra PJ, McKim D, Benditt J, Winck JA-O, Nasilowski J, et al. Building a home ventilation programme: population, equipment, delivery and cost. *Thorax*. 2022; 77:1140-8. doi: <https://doi.org/10.1136/thoraxjnl-2021-218410>.

To submit the next your paper with us at:
<https://he02.tci-thaijo.org/index.php/cc/about/submissions>

