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Systematic review

Mechanical ventilation management and ICU workflows: a systematic review of clinical practices led by ICU respiratory therapists and respiratory care education supervisors

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Abstract

Background: Mechanical ventilation requires adjustment, timely liberation assessment, and coordination in intensive care unit teams. Respiratory therapists occupy important operational position, while respiratory care education supervisors influence protocol competence, audit readiness, and practice consistency. This review evaluated therapist-led clinical practices for improving ventilation management and intensive care outcomes. **Methods:** A systematic review framework followed PRISMA principles. PubMed, Scopus, Web of Science Core Collection, and Cochrane sources were searched for adult or pediatric intensive care studies evaluating respiratory therapist-led ventilation protocols, liberation pathways, standardized order sets, ventilator bundles, or structured competency support. Eligible studies reported clinical, process, safety, or implementation outcomes. **Results:** Thirteen studies published between 1995 and 2024 were included. Therapist-led protocols shortened ventilation or weaning time, accelerated

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spontaneous breathing assessment, improved adherence to lung-protective targets, and strengthened protocol execution. Several studies reported unchanged mortality, reintubation, intensive care length of stay, or total ventilation duration, especially where baseline staffing was strong or protocol adherence was limited. Education, repeated feedback, electronic decision support, and clearly delegated authority were prominent implementation components. **Conclusion:** Respiratory therapist-led ventilation management improves workflow reliability and selected clinical outcomes without consistent evidence of harm. Effects depend on local staffing, protocol fidelity, multidisciplinary agreement, and ongoing competency supervision. Respiratory care education supervisors provide infrastructure for training, performance feedback, and sustained implementation.

Keywords: Mechanical ventilation; respiratory therapist; ICU workflow; ventilator liberation; spontaneous breathing trial; lung-protective ventilation; protocol-driven care; respiratory care education.

Introduction

Mechanical ventilation sustains gas exchange during severe respiratory failure, although excessive tidal volume, oxygen exposure, driving pressure, sedation, and delayed liberation contribute to secondary lung injury and prolonged critical illness (1). International cohorts show that mechanically ventilated patients represent a heterogeneous population with mortality and wide practice variation in intensive care units (ICU) (2). Ventilation requires frequent bedside assessment because patient physiology, ventilator interaction, secretion burden, and readiness for spontaneous breathing change throughout each shift (1). These operational demands place respiratory therapists at the intersection of monitoring, device adjustment, airway care, emergency response, and multidisciplinary communication (2).

Guidelines for acute respiratory distress syndrome emphasize lower tidal volumes, limitation of inspiratory pressures, appropriate positive end-expiratory pressure, and prone positioning in severe hypoxemia (3). Liberation guidance supports protocolized assessment, spontaneous breathing trials, sedation minimization, and early mobilization as coordinated processes rather than separate decisions (4). A Cochrane review found that protocolized weaning reduced total ventilation duration, weaning duration, and intensive care stay across pooled adult trials, with substantial heterogeneity between units and protocols (5).

Respiratory therapist-led models delegate defined ventilator adjustments, screening decisions, spontaneous breathing trials, and escalation steps to trained practitioners working within approved algorithms (4). The professional vision for advanced respiratory care identifies disease management, protocol implementation, patient assessment, interprofessional leadership, and quality improvement as core responsibilities of the modern therapist (6). Graduate competency frameworks require proficiency in mechanical ventilation (MV), waveform interpretation, evidence appraisal, protocol use, communication, and team leadership, linking bedside performance with education oversight (7).

Existing reviews examined weaning protocols in mixed professional groups, while less attention has focused on the combined contribution of ICU respiratory therapists and education supervision to ventilation workflows (5). The present systematic review synthesized original studies evaluating therapist-led mechanical ventilation management, ventilator liberation, spontaneous breathing testing, lung-protective order sets, and ventilator bundles.

Methods

Design and Reporting

This systematic review was prepared according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework. The review question used a population, intervention, comparator, and outcome structure. The population comprised invasively ventilated adults or children in ICU settings; interventions comprised respiratory therapist-led ventilation management, weaning, extubation-readiness testing, ventilator bundles, standardized order sets, electronic decision support, or education-supported protocol implementation; comparators comprised physician-directed care, usual care, historical practice, or an alternative protocol; outcomes included ventilation duration, weaning time, spontaneous breathing trial performance, extubation failure, ventilator-associated pneumonia, lung-protective adherence, intensive care length of stay, mortality, safety, and workflow measures.

Search Strategy

Searches covered PubMed, Scopus, Web of Science Core Collection, and the Cochrane Library from January 1990 through Jun, 2026. Search concepts combined controlled vocabulary and keywords for "mechanical ventilation," "ventilator weaning," "spontaneous breathing trial," "extubation readiness," "lung-protective ventilation," "respiratory therapist," "respiratory care practitioner," "protocol-driven," "education," "competency," "supervisor," and "intensive care unit." Reference lists of eligible reports and relevant systematic reviews were examined for additional studies. Searches were restricted to human research published in English.

Eligibility and Selection

Randomized trials, prospective or retrospective comparative studies, cohort studies, and quality-improvement evaluations were eligible. We exclude studies limited to noninvasive ventilation, chronic home ventilation, operating-room ventilation, transport ventilation, or purely physiological testing without a workflow intervention. Reviews, guidelines, editorials, conference abstracts lacking complete outcome data, case reports, and simulation studies without patient or workflow outcomes were also excluded. Titles and abstracts were screened against prespecified criteria. Full articles were retrieved when eligible, followed by full-text eligibility assessment and consensus resolution of uncertain records.

Data Extraction and Quality Assessment

Data were extracted into a structured form covering country, setting, population, design, sample size, therapist role, education or implementation strategy, comparator, outcomes, and adverse events. Randomized studies were assessed in randomization, deviations from assigned intervention, missing data, outcome measurement, and selective reporting domains. Nonrandomized studies were assessed for confounding, selection, intervention classification, missing data, outcome measurement, and reporting bias, while quality-improvement studies were additionally reviewed for intervention clarity, temporal measurement, implementation fidelity, and sustainability. Because interventions, populations, designs, and outcome definitions differed substantially, findings were synthesized narratively rather than pooled statistically.

Results

Thirteen studies met the eligibility criteria, including adult and pediatric ICUs from 1995 through 2024 (8). An early cardiac-surgery comparison found that a respiratory therapist-directed protocol achieved safe and efficient ventilator withdrawal relative to physician-directed practice (8). In a randomized trial of 357 adults, protocol-directed weaning by nurses and respiratory therapists reduced median ventilation duration from 44 to 35 hours (9). A 1,067-patient implementation study involving 117 respiratory care practitioners showed that a validated daily screen plus spontaneous breathing trial pathway was feasible (10).

A multidisciplinary protocol delivered by respiratory care practitioners and nurses reduced median ventilation duration from 124 to 68 hours, with no adverse signal and a lower numerical burden of surgical ventilator-associated pneumonia (11). In pediatric intensive care, prospective randomization found shorter weaning time with protocol-directed care than with physician-directed care, supporting pediatric delegation (12). A handheld protocol shortened time to the first spontaneous breathing trial from 72.5 to 49.9 hours, increased timely trials from 63.6% to 89.8%, and reduced intensive care stay from 7.7 to 6.2 days (13). In surgical and trauma populations, protocol implementation reduced ventilator utilization from 0.47 to 0.33 ventilator-days per ICU-day, lowered failed extubations, and reduced ventilator-associated pneumonia episodes without shortening ICU stay (14).

An expanded ventilator bundle incorporating respiratory therapist-driven elements reduced median ventilator-associated pneumonia rates from 14.1 to 0 cases per 1,000 ventilator-days in a medical ICU (15). Among 118 adults managed through an established therapist-driven pathway, automatic tube compensation produced fewer first-trial failures than continuous positive airway pressure numerically (16). A pediatric quality-improvement study involving 219 patients achieved protocol introduction, although screening adherence was 56.4% and no significant improvement occurred in first-trial timing, ventilation duration, or ICU stay (17). A goal-directed order set implemented by respiratory therapists in 1,693 ventilation episodes increased order-set compliance from 3.8% to 88.2% and improved adherence to the ARDS Network PEEP/FIO2 table (18).

A later pediatric initiative used four Plan-Do-Study-Act cycles, increased respiratory therapist-led extubation-readiness testing from 0% to 90%, reduced extubation failure from 12.9% to 2.4%, and shortened pediatric ICU stay without destabilization (19). The newest adult cohort included 666 patients and found higher overall adherence to lung-protective ventilation after a therapist-driven bundle, with an adjusted odds ratio of 2.48 and a lower adjusted incidence of acute respiratory distress syndrome (20). Benefits were most consistent for process reliability, earlier assessment, ventilation exposure, and adherence, whereas mortality and reintubation effects were usually neutral (9). Risk-of-bias appraisal identified some concern from absent blinding in randomized

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studies and moderate-to-serious confounding in before-after studies affected by concurrent initiatives, secular trends, or incomplete adherence.

Table 1. Characteristics and Main Findings of the Included Studies

Study	Design and setting	Therapist-led practice	Principal result
Wood, 1995 (8)	Comparative cardiac-surgery study	Written RT-directed weaning protocol	Total ventilation time was shorter during implementation phases, with no protocol complications.
Kollef, 1997 (9)	Multicenter randomized trial; 357 adults	Nurse- and RT-directed weaning	Median ventilation duration was 35 versus 44 hours; mortality was similar.
Ely, 1999 (10)	Prospective implementation study; 1,067 adults	Daily screening and SBT pathway delivered by 117 RCPs	Large-scale delivery was feasible; repeated education and feedback reinforced adherence.
Marelich, 2000 (11)	Prospective controlled study; 335 medical and surgical patients	RCP- and nurse-delivered ventilator management protocol	Median ventilation duration was 68 versus 124 hours, with an acceptable safety profile.
Schultz, 2001 (12)	Prospective randomized pediatric study	Protocol-directed weaning	Weaning time was shorter after stratification by respiratory diagnosis.
Iregui, 2002 (13)	Medical ICU before-and-after study	Handheld electronic weaning protocol	Time to the first SBT, timely trial performance, and ICU length of stay improved.
Dries, 2004 (14)	Surgical and trauma ICU implementation study	Protocol-driven assessment and ventilator liberation	Ventilator utilization, early reintubation, and VAP decreased; ICU length of stay was unchanged.
Blamoun, 2009 (15)	Medical ICU before-and-after study	Expanded ventilator bundle with RT-driven components	The median VAP rate decreased from 14.1 to 0 cases per 1,000 ventilator-days.
Figueroa-Casas, 2010 (16)	Randomized trial; 118 adults	ATC versus CPAP within an RT-driven pathway	First-trial failure was numerically lower with ATC; major liberation outcomes were similar.
Krawiec, 2017 (17)	Pediatric quality-improvement study; 219 patients	RT-led SBT-readiness screening	Adherence reached 56.4%; SBT timing, ventilation duration, and ICU length of stay were unchanged.
Radosevich, 2019 (18)	Controlled before-and-after study; 1,302 patients and 1,693 ventilation episodes	RT-implemented goal-directed order set	Order-set compliance and PEEP/FIO2-table adherence increased; mortality and length-of-stay outcomes were unchanged.
Tan, 2022 (19)	Pediatric quality-improvement project; 438 admissions	RT-championed ERT pathway using four PDSA cycles	ERT performance reached 90%, extubation failure decreased, and no patient experienced destabilization.
Berg, 2024 (20)	Retrospective pre-post cohort study; 666 adults	RT-driven lung-protective ventilation bundle	Overall adherence increased, and the adjusted incidence of ARDS decreased.

Table 2. Analysis of outcomes

Outcome domain	Contributing studies	Direction of findings	Interpretation
Ventilation and weaning duration	(8)–(14)	Favorable in several adult and pediatric studies; neutral in selected organized ICUs	Moderate confidence, limited by heterogeneous definitions and settings

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Outcome domain	Contributing studies	Direction of findings	Interpretation
SBT and ERT workflow	(10), (13), (16), (17), (19)	Earlier or more reliable testing in several studies; clinical effects varied	Moderate confidence for process outcomes
Lung-protective ventilation	(18), (20)	Higher order-set, PEEP/FIO2, and overall protocol adherence	Low-to-moderate confidence from before-after designs
VAP and safety	(11), (14)–(16), (19), (20)	VAP decreased in several cohorts; no consistent adverse safety signal	Low-to-moderate confidence
Mortality, reintubation, and length of stay	(9), (13), (14), (16)–(20)	Mostly neutral, with selected ICU-stay and extubation-failure improvements	Low confidence because outcomes were multifactorial
Education and implementation	(10), (13), (17)–(20)	Repeated training, audit feedback, electronic support, and iterative cycles accompanied stronger fidelity	Indirect evidence; no study isolated the supervisor effect

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Discussion

This review indicates that respiratory therapist-led ventilation practices improve ICU workflow most reliably when protocols convert data into immediate bedside actions (9). The strongest recurring effects involved earlier spontaneous breathing assessment, shorter ventilation exposure, higher protocol adherence, and more consistent use of lung-protective settings (11). Mortality, reintubation, and ICU length of stay were less responsive, reflecting their dependence on illness severity, sedation, staffing, discharge capacity, and extubation decisions (14). A controlled study in a closed medical ICU with structured rounds found no added outcome advantage from protocolized discontinuation, illustrating that the incremental value of delegation decreases when baseline practice is already organized and intensively staffed (21).

Implementation fidelity emerged as a central determinant of effectiveness across adult and pediatric settings (10). High adherence accompanied process gains in electronic decision support and standardized order-set studies, while limited screening adherence weakened the pediatric spontaneous breathing trial intervention (13). Interprofessional research on extubation delays identifies uncertainty, workflow timing, provider availability, communication gaps, and concern regarding failed extubation as modifiable contributors after successful spontaneous breathing testing (22).

Respiratory care education supervisors occupy a critical implementation position because protocol delegation requires verified knowledge, supervised practice, and continuing performance review (7). Education programs need to address ventilator modes, tidal-volume selection, PEEP/FIO2 titration, driving pressure, alarm interpretation, patient-ventilator synchrony, spontaneous breathing trials, extubation-risk recognition, and emergency troubleshooting (7). An international survey of 1,832 ICU professionals found that only 53% correctly interpreted at least 60% of tested ventilator waveforms, while respiratory therapist profession, prior waveform training, graduate education, teaching-hospital employment, and longer ICU experience were associated with stronger performance (23).

Mechanical ventilation competency statements for advanced respiratory therapists emphasize assessment, ventilator selection, monitoring, synchrony management, liberation, evidence use, and communication across the care team (24). The included studies suggest that one-time education is insufficient, because successful programs used repeated feedback, staged implementation, electronic prompts, champions, or iterative Plan-Do-Study-Act cycles.

The evidence has limitations arising from heterogeneous populations, interventions, outcomes, and professional role definitions (5). Many reports used single-center before-after designs, creating vulnerability to secular trends, cointerventions, and regression toward the mean (20). Protocols also differed in screening criteria, spontaneous breathing trial technique, extubation authority, sedation integration, and nighttime availability, which restricted quantitative pooling (16). Recent randomized evidence shows that neither greater screening frequency nor a single spontaneous breathing trial technique uniformly accelerates successful extubation, reinforcing the importance of local workflow evaluation rather than assuming universal superiority of one pathway (25).

Conclusion

Respiratory therapist-led MV protocols strengthen ICU workflow by standardizing assessment, ventilator adjustment, spontaneous breathing testing, extubation readiness, and lung-protective practice. Successful implementation depends on delegated authority, multidisciplinary agreement, documentation, adequate staffing, and sustained education. Respiratory care education supervisors support these requirements through competency validation, simulation, audit feedback, remediation, and performance monitoring.

List of Abbreviations

ARDS, acute respiratory distress syndrome; ATC, automatic tube compensation; CI, confidence interval; CPAP, continuous positive airway pressure; ERT, extubation-readiness test; FIO2, fraction of inspired oxygen; ICU, intensive care unit; MV, mechanical ventilation; NIV, noninvasive ventilation; OR, odds ratio; PDSA, Plan-Do-Study-Act; PEEP, positive end-expiratory pressure; PICU, pediatric intensive care unit; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCP, respiratory care practitioner; RCT, randomized controlled trial; RT, respiratory therapist; SBT, spontaneous breathing trial; VAP, ventilator-associated pneumonia; VFD, ventilator-free day; WoS, Web of Science.

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