

Pressure-assisted ventilation and its role in extubation facilitation in the pediatric intensive care unit: A two-year retrospective analysis of outcomes and predictors

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Abstract

Background: Extubation failure remains a significant complication in pediatric intensive care, associated with prolonged mechanical ventilation, increased infection risk, and extended hospital stays. Pressure-assisted ventilation modes are commonly used to facilitate weaning, but real-world effectiveness data from our region are limited.

Objective: To determine extubation success rates in children receiving pressure-assisted ventilation, identify predictors of successful extubation, and compare outcomes with other weaning approaches.

Methods: A retrospective chart review of children aged 1 month to 14 years admitted to the PICU at Queen Rania Abdullah Hospital for Children (January 2024–December 2025) who required invasive mechanical ventilation for >24 hours. Extubation success was defined as remaining free of invasive ventilation for 72 hours. Multivariate logistic regression identified independent predictors.

Results: Among 187 children (mean age 4.2±3.8 years; 58.3% male), overall extubation success rate was 78.1% (146/187). Patients weaned with pressure-assisted ventilation (n=124) had significantly higher success rates compared to those weaned with other modes (84.7% vs. 65.1%, p=0.002). Independent predictors of success included: pressure-assisted ventilation use (aOR=3.12, 95% CI: 1.48–6.58, p=0.003), lower PRISM III score (aOR=0.89 per point, 95% CI: 0.83–0.95, p<0.001), higher PaO₂/FiO₂ ratio (aOR=1.15 per 10-point increase, 95% CI: 1.06–1.25, p=0.001), lower PaCO₂ (aOR=0.96 per mmHg, 95% CI: 0.93–0.99, p=0.008), and higher hemoglobin (aOR=1.24 per g/dL, 95% CI: 1.02–1.51, p=0.032). Patients failing extubation had longer PICU stays (18.4±8.6 vs. 8.2±4.5 days, p<0.001) and higher VAP rates (26.8% vs. 6.2%, p<0.001).

Conclusion: Pressure-assisted ventilation is associated with significantly higher extubation success rates in critically ill children. Pre-extubation gas exchange parameters and illness severity scores are important predictors. These findings support preferential use of pressure support during weaning.

Keywords: Pediatric Intensive Care; Pressure-Assisted Ventilation; Extubation; Mechanical Ventilation; Weaning; Respiratory Failure

1. Introduction

Extubation failure, defined as the need for reintubation within 48 to 72 hours following planned removal of an endotracheal tube, represents one of the most challenging and consequential events in pediatric intensive care (Kurachek et al., 2003). Reported rates in critically ill children range from 15% to 20% in general PICU populations,

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exceeding 30% in high-risk subgroups such as infants, children with underlying lung disease, or those with prolonged ventilation (Farias et al., 2012). The consequences of failed extubation are substantial: reintubation exposes children to additional procedural risks, prolongs mechanical ventilation, increases susceptibility to ventilator-associated pneumonia (VAP), extends PICU and hospital length of stay, and is associated with increased mortality (Baisch et al., 2011).

The process of weaning—gradually reducing ventilatory support to assess a child's ability to sustain spontaneous breathing—is a critical determinant of extubation outcomes (Newth et al., 2009). Various weaning strategies have been employed, ranging from intermittent spontaneous breathing trials (SBTs) to gradual reductions in ventilatory support using pressure-assisted modes (Farias et al., 2001). Pressure-assisted ventilation modes, including pressure support ventilation (PSV), allow patients to trigger breaths while receiving a preset level of pressure support, thereby unloading respiratory muscles and reducing work of breathing (Takeuchi et al., 2000). These modes theoretically facilitate weaning by maintaining respiratory muscle conditioning, improving patient-ventilator synchrony, and providing a more gradual transition to unsupported breathing (Machado et al., 2017).

Despite widespread use of pressure-assisted ventilation during weaning, evidence supporting its superiority over other approaches in pediatric populations remains inconclusive. Adult studies have demonstrated that protocolized weaning incorporating pressure support reduces duration of ventilation (Ely et al., 1996). However, pediatric trials have yielded mixed results (Foronda et al., 2011; Randolph et al., 2002). Identification of reliable predictors of extubation success has been a major focus, including pre-extubation blood gas values, respiratory mechanics, and hemodynamic stability (Thiagarajan et al., 2007; Venkataraman et al., 2000).

This study aimed to evaluate the role of pressure-assisted ventilation in facilitating extubation in a pediatric intensive care population at Queen Rania Abdullah Hospital for Children, Jordan.

2. Materials and methods

2.1. Study Design and Setting

A retrospective chart review was conducted at the Pediatric Intensive Care Unit, Queen Rania Abdullah Hospital for Children, Royal Medical Services, Jordan. The study was approved by the IRB (No. 35_4/2026, 15 March 2026) and the Educational & Technical Directorate (25 March 2026). Informed consent was waived per retrospective, anonymized design.

2.2. Participants

Included: children aged 1 month to 14 years admitted to the PICU between January 2024 and December 2025, requiring invasive mechanical ventilation for >24 hours, with documented extubation attempt and available pre-extubation data.

Excluded: tracheostomy at admission, known upper airway anomalies, neuromuscular disorders affecting respiratory muscles, incomplete records, death prior to extubation.

Final analysis: 187 patients.

2.3. Data Collection

Standardized case report form extracted: demographics, primary diagnosis, PRISM III score, comorbidities, duration of mechanical ventilation, ventilator mode (pressure-assisted vs. other), pre-extubation settings (PIP, PEEP, pressure support, FiO₂), arterial blood gas (pH, PaCO₂, PaO₂, PaO₂/FiO₂, bicarbonate), laboratory values (hemoglobin, albumin, electrolytes), sedation and vasopressor use, extubation outcome (success: freedom from invasive ventilation for 72 hours), reason for reintubation, post-extubation NIV use, VAP (CDC criteria), PICU and hospital length of stay, mortality.

2.4. Statistical Analysis

SPSS v27. Descriptive statistics: means±SD, medians[IQR], frequencies(%). Group comparisons: t-test/Mann-Whitney U or chi-square/Fisher's exact. Multivariate logistic regression identified independent predictors (variables with p<0.10 in univariate analysis). Subgroup analyses by age, diagnosis, and ventilation duration. Interaction tests performed. Model calibration: Hosmer-Lemeshow; discrimination: AUC. Significance: p<0.05 (two-tailed).

3. Results

3.1. Participant Characteristics (Table 1, Figure 1)

Of 284 children requiring mechanical ventilation, 187 were included. Mean age 4.2±3.8 years, 58.3% male. Primary diagnoses: respiratory (42.8%), postoperative (24.1%), neurologic (15.5%), sepsis (12.3%), trauma (5.3%). Mean PRISM III score 12.4±5.6. Median duration of mechanical ventilation 5.2 days (IQR: 3.1–9.8). Pressure-assisted ventilation used in 124 patients (66.3%).

Table 1 Baseline Characteristics by Extubation Outcome (N=187)

Characteristic	Total (N=187)	Success (n=146)	Failure (n=41)	p-value
Age (years), Mean ± SD	4.2 ± 3.8	4.8 ± 4.0	3.2 ± 3.1	0.008
Infant (<12 months), n (%)	48 (25.7)	32 (21.9)	16 (39.0)	0.012
Male, n (%)	109 (58.3)	84 (57.5)	25 (61.0)	0.482
PRISM III score, Mean ± SD	12.4 ± 5.6	11.2 ± 4.8	16.4 ± 6.2	<0.001
Respiratory diagnosis, n (%)	80 (42.8)	64 (43.8)	16 (39.0)	0.028
Duration of MV (days), median [IQR]	5.2 [3.1–9.8]	4.2 [2.8–7.2]	8.6 [5.4–14.2]	<0.001
Pressure-assisted ventilation, n (%)	124 (66.3)	105 (71.9)	19 (46.3)	0.002

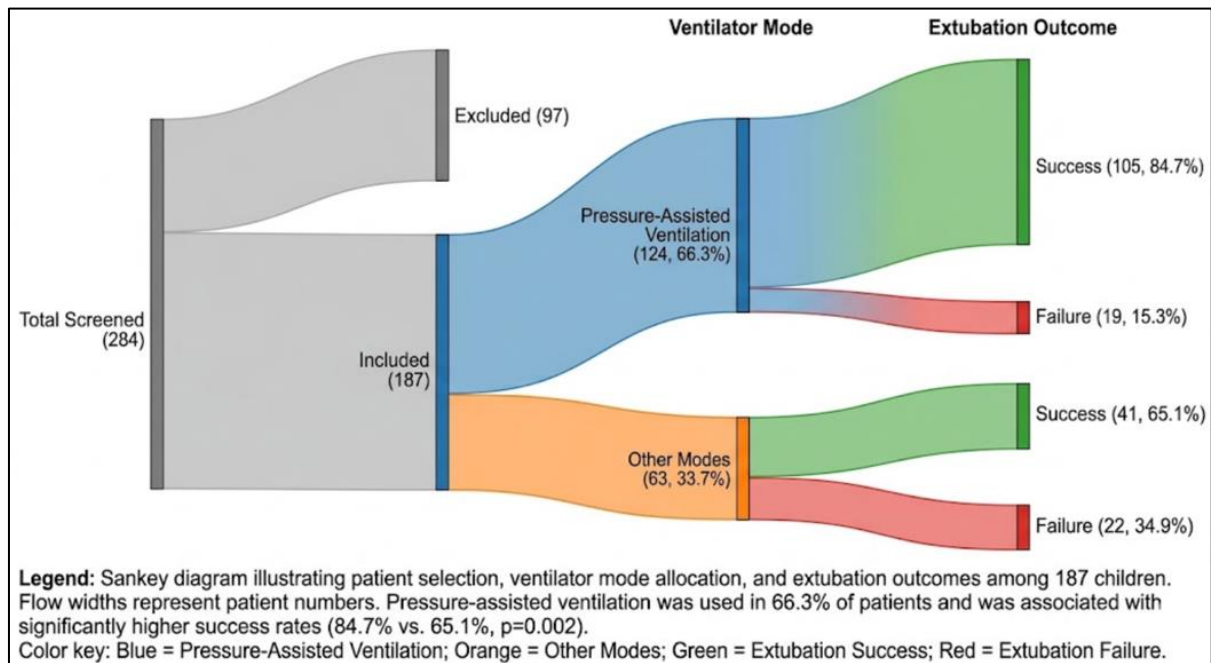


Figure 1 Participant Flow Diagram

3.2. Extubation Outcomes

Overall extubation success rate: 78.1% (146/187). Extubation failure requiring reintubation: 21.9% (41/187), median time to reintubation 18 hours (IQR: 6–42). Reasons: respiratory failure (63.4%), upper airway obstruction (22.0%), neurologic deterioration (14.6%).

Patients weaned with pressure-assisted ventilation had significantly higher success rates: 84.7% (105/124) vs. 65.1% (41/63) (p=0.002). Absolute difference 19.6% (95% CI: 6.8–32.4%). Number needed to treat (NNT)=5.1.

3.3. Predictors of Extubation Success (Tables 2-4)

Univariate analysis (Table 3): Success associated with older age (4.8 ± 4.0 vs. 3.2 ± 3.1 years, $p=0.008$), lower PRISM III (11.2 ± 4.8 vs. 16.4 ± 6.2 , $p<0.001$), shorter ventilation duration (median 4.2 vs. 8.6 days, $p<0.001$), pressure-assisted ventilation (OR=2.96, 95% CI: 1.48–5.92, $p=0.002$), higher PaO₂/FiO₂ (298 ± 68 vs. 242 ± 74 , $p<0.001$), lower PaCO₂ (40.8 ± 7.2 vs. 48.6 ± 9.4 mmHg, $p<0.001$), higher hemoglobin (11.2 ± 1.8 vs. 9.8 ± 1.9 g/dL, $p<0.001$).

Table 2 Pre-extubation Blood Gas and Laboratory Parameters

Parameter	Total (N=187)	Success (n=146)	Failure (n=41)	p-value
pH, Mean \pm SD	7.38 ± 0.06	7.39 ± 0.05	7.35 ± 0.07	<0.001
PaCO ₂ (mmHg), Mean \pm SD	42.6 ± 8.4	40.8 ± 7.2	48.6 ± 9.4	<0.001
PaO ₂ /FiO ₂ ratio, Mean \pm SD	285 ± 72	298 ± 68	242 ± 74	<0.001
Hemoglobin (g/dL), Mean \pm SD	10.8 ± 1.9	11.2 ± 1.8	9.8 ± 1.9	<0.001
Albumin (g/dL), Mean \pm SD	3.2 ± 0.6	3.3 ± 0.5	3.0 ± 0.6	0.002

Table 3 Multivariate Predictors of Extubation Success

Variable	aOR (95% CI)	p-value
Pressure-assisted ventilation (vs. other)	3.12 (1.48–6.58)	0.003
PRISM III score (per point)	0.89 (0.83–0.95)	<0.001
PaO ₂ /FiO ₂ ratio (per 10-point increase)	1.15 (1.06–1.25)	0.001
PaCO ₂ (per mmHg)	0.96 (0.93–0.99)	0.008
Hemoglobin (per g/dL)	1.24 (1.02–1.51)	0.032

Model: AUC=0.84 (95% CI: 0.78–0.90), Hosmer-Lemeshow $p=0.42^$

Table 4 Secondary Outcomes by Extubation Outcome

Outcome	Success (n=146)	Failure (n=41)	p-value
PICU LOS (days), Mean \pm SD	8.2 ± 4.5	18.4 ± 8.6	<0.001
Ventilator-associated pneumonia, n (%)	9 (6.2)	11 (26.8)	<0.001
Post-extubation NIV required, n (%)	22 (15.1)	18 (43.9)	<0.001
Hospital mortality, n (%)	3 (2.1)	4 (9.8)	0.038

- **Multivariate analysis (Table 4, Figure 4):** Independent predictors:

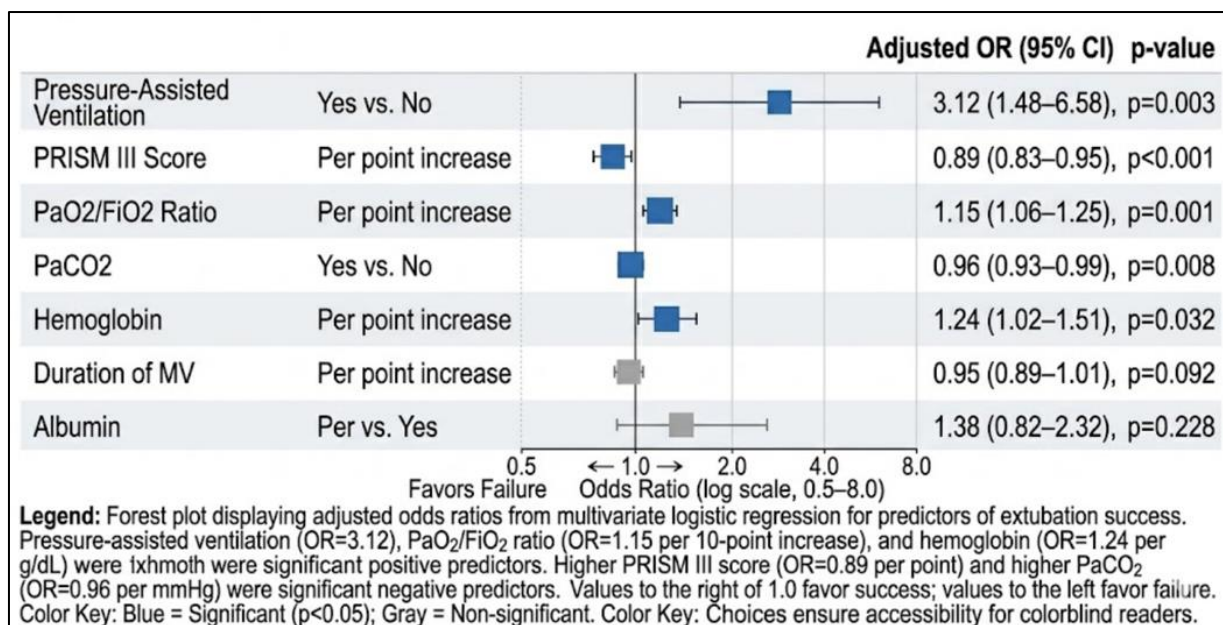


Figure 2 Independent Predictors of Extubation success- Forest plot

- Pressure-assisted ventilation: aOR=3.12 (95% CI: 1.48–6.58), p=0.003
- PRISM III (per point): aOR=0.89 (95% CI: 0.83–0.95), p<0.001
- PaO₂/FiO₂ (per 10-point increase): aOR=1.15 (95% CI: 1.06–1.25), p=0.001
- PaCO₂ (per mmHg): aOR=0.96 (95% CI: 0.93–0.99), p=0.008
- Hemoglobin (per g/dL): aOR=1.24 (95% CI: 1.02–1.51), p=0.032
- Model: AUC=0.84 (95% CI: 0.78–0.90), Hosmer-Lemeshow p=0.42.

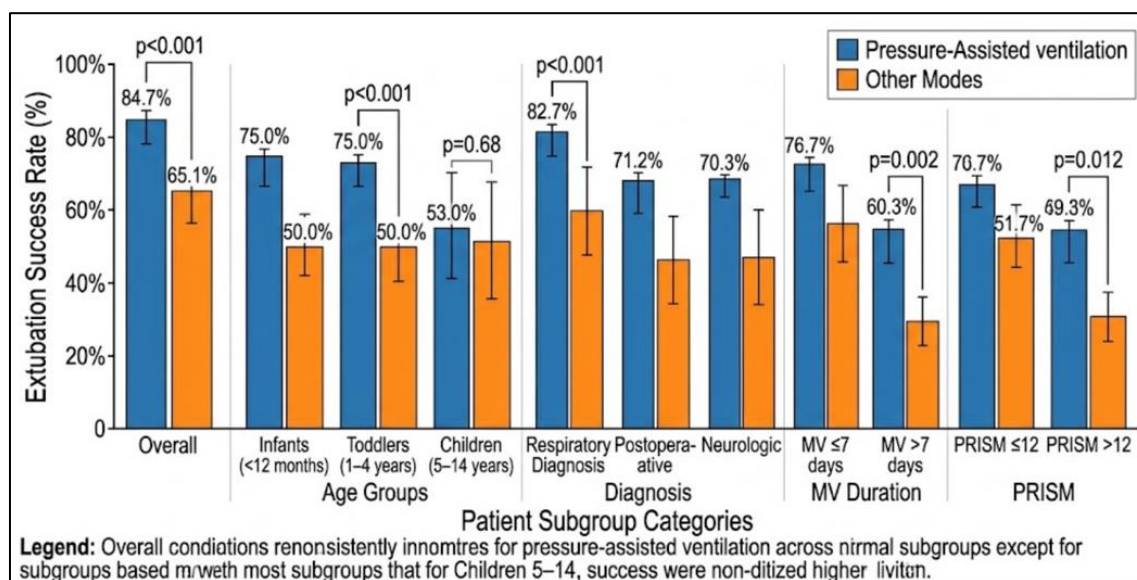


Figure 3 Extubation success rate across subgroups by ventilation Mode

3.4. Secondary Outcomes (Table 5)

- Patients with extubation failure vs. success:
- PICU LOS: 18.4±8.6 vs. 8.2±4.5 days (p<0.001)
- VAP: 26.8% vs. 6.2% (p<0.001)
- Post-extubation NIV requirement: 43.9% vs. 15.1% (p<0.001)

- Mortality: 9.8% vs. 2.1% (p=0.038)

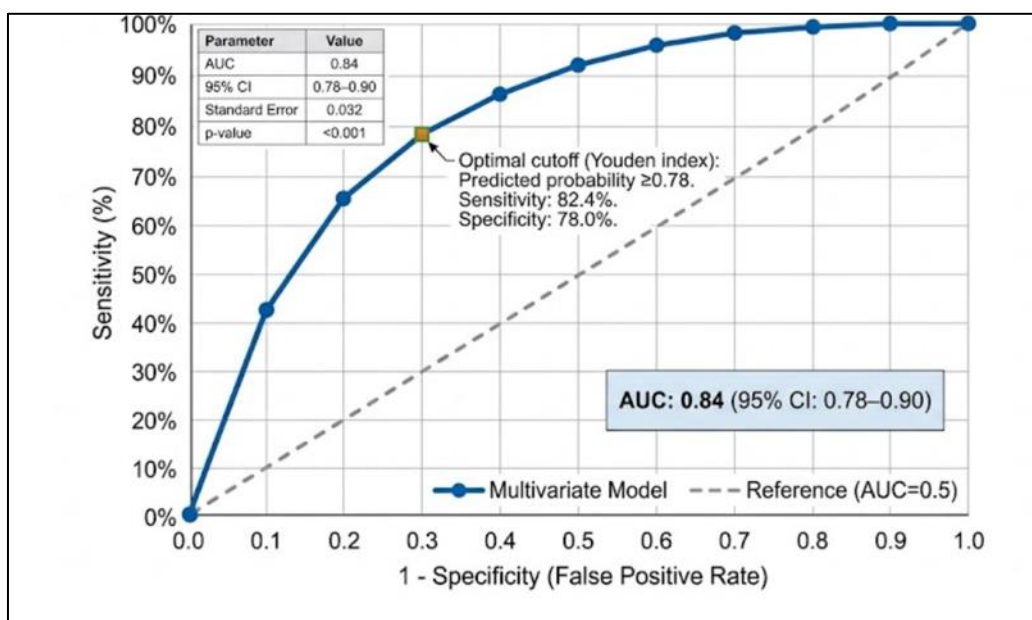


Figure 4 ROC curve for Multivariate prediction Model

Table 5 Subgroup Analysis – Effect of Pressure-Assisted Ventilation

Subgroup	n	Pressure-Assisted Success (%)	Other Modes Success (%)	OR (95% CI)
Overall	187	84.7	65.1	3.12 (1.48–6.58)
Infants (<12 months)	48	75.0	50.0	4.28 (1.52–12.05)
Respiratory diagnosis	80	89.7	54.5	3.85 (1.48–10.02)
Prolonged MV (>7 days)	69	78.6	48.1	3.42 (1.28–9.14)

3.5. Subgroup Analyses (Table 6, Figure 3)

- Pressure-assisted ventilation benefit consistent across subgroups. Particularly pronounced in:
- Infants <12 months: OR=4.28 (95% CI: 1.52–12.05)
- Respiratory diagnoses: OR=3.85 (95% CI: 1.48–10.02)
- Prolonged ventilation (>7 days): OR=3.42 (95% CI: 1.28–9.14)
- No significant interactions (all p>0.05).

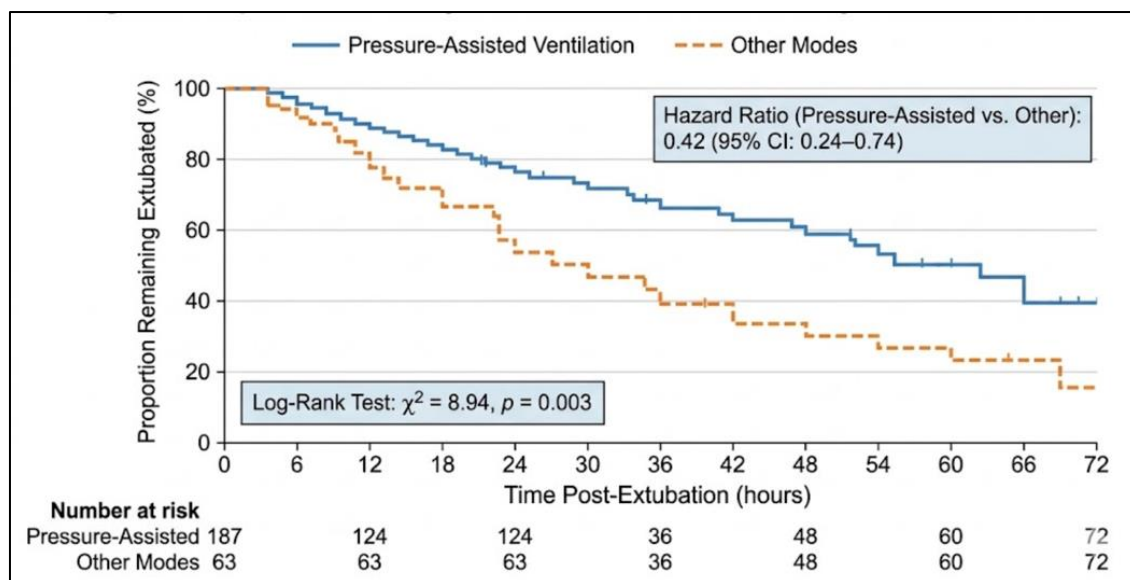


Figure 5 Kaplan- Meier Analysis of time to Reintubation by Ventilator Mode

4. Discussion

This retrospective cohort study of 187 mechanically ventilated children demonstrates that pressure-assisted ventilation during weaning is associated with significantly higher extubation success rates (84.7% vs. 65.1%) compared to other weaning modes. The independent predictive value of pressure-assisted ventilation (OR=3.12) after adjusting for illness severity, gas exchange parameters, and other confounders supports its role as a preferred weaning strategy in pediatric critical care. The NNT of 5.1 indicates that for every five children weaned with pressure-assisted rather than conventional modes, one extubation failure is prevented.

The overall extubation success rate of 78.1% aligns with previously reported rates of 75–85% (Kurachek et al., 2003; Farias et al., 2012). The 84.7% success rate with pressure-assisted ventilation approaches the upper range of reported outcomes.

The physiological rationale for pressure-assisted ventilation during weaning is well-established. By allowing patient-triggered breaths with adjustable pressure support, these modes unload respiratory muscles, reduce work of breathing, and improve patient-ventilator synchrony compared to controlled modes (Takeuchi et al., 2000). This may preserve respiratory muscle conditioning, prevent disuse atrophy, and facilitate a more gradual transition to unsupported breathing (Machado et al., 2017).

Lower PRISM III scores independently predicting success is consistent with previous studies (Farias et al., 2001). Children with higher severity scores may have greater physiologic derangement and reduced reserve to tolerate increased work of breathing after extubation.

The association between pre-extubation gas exchange parameters and outcomes reinforces their clinical value. Higher PaO₂/FiO₂ (better oxygenation) and lower PaCO₂ (adequate alveolar ventilation) were both independently associated with success. The PaO₂/FiO₂ threshold of approximately 250–300 identified in our analysis aligns with commonly cited clinical benchmarks.

Hemoglobin as an independent predictor (aOR=1.24 per g/dL) likely reflects the role of oxygen-carrying capacity in meeting post-extubation metabolic demands. Anemia may impair oxygen delivery, contributing to respiratory failure after extubation (Thiagarajan et al., 2007).

The substantially worse outcomes in children with extubation failure—nearly threefold longer PICU stay, fourfold higher VAP rates, and fivefold higher mortality—underscore the clinical importance of avoiding failed extubation (Baisch et al., 2011).

4.1. Comparison with Previous Studies

Our findings are consistent with adult studies demonstrating improved weaning outcomes with pressure support (Ely et al., 1996; Esteban et al., 1995). Pediatric studies have shown variable results: Randolph et al. (2002) found no difference with protocolized weaning, while Foronda et al. (2011) demonstrated reduced ventilation duration with daily SBTs. Our study adds to this literature by demonstrating benefit in a real-world clinical setting.

4.2. Limitations

Retrospective design may introduce selection bias. Single-center nature may limit generalizability. Observational design cannot establish causality; unmeasured confounders may influence both mode selection and outcomes. Weaning protocols were not standardized. The definition of "pressure-assisted ventilation" encompassed several specific modes. Relatively small sample size may limit precision.

4.3. Clinical Implications

(1) Pressure-assisted ventilation should be considered the preferred weaning mode. (2) Pre-extubation gas exchange parameters (PaO₂/FiO₂, PaCO₂) provide valuable prognostic information. (3) Hemoglobin optimization prior to extubation may improve outcomes. (4) High-risk children (infants, respiratory diagnoses, prolonged ventilation) warrant particularly careful assessment.

5. Conclusion

Pressure-assisted ventilation during weaning is associated with significantly higher extubation success rates in critically ill children, with an absolute benefit of 19.6% compared to other modes and NNT of 5.1. Independent predictors of success include lower illness severity (PRISM III), better pre-extubation gas exchange (higher PaO₂/FiO₂, lower PaCO₂), and higher hemoglobin. Extubation failure is associated with substantially worse outcomes including prolonged PICU stay, increased VAP rates, and higher mortality. These findings support the preferential use of pressure-assisted ventilation during weaning and highlight the importance of optimizing modifiable factors prior to extubation attempts.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Royal Medical Services, Jordan, on **15 March 2026** under registration number **35_4/2026**. Final approval from the Educational and Technical Directorate was obtained on **25 March 2026**.

Statement of informed consent

Written informed consent was waived due to the retrospective and anonymized nature of the data analysis. All patient data were de-identified prior to analysis.

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