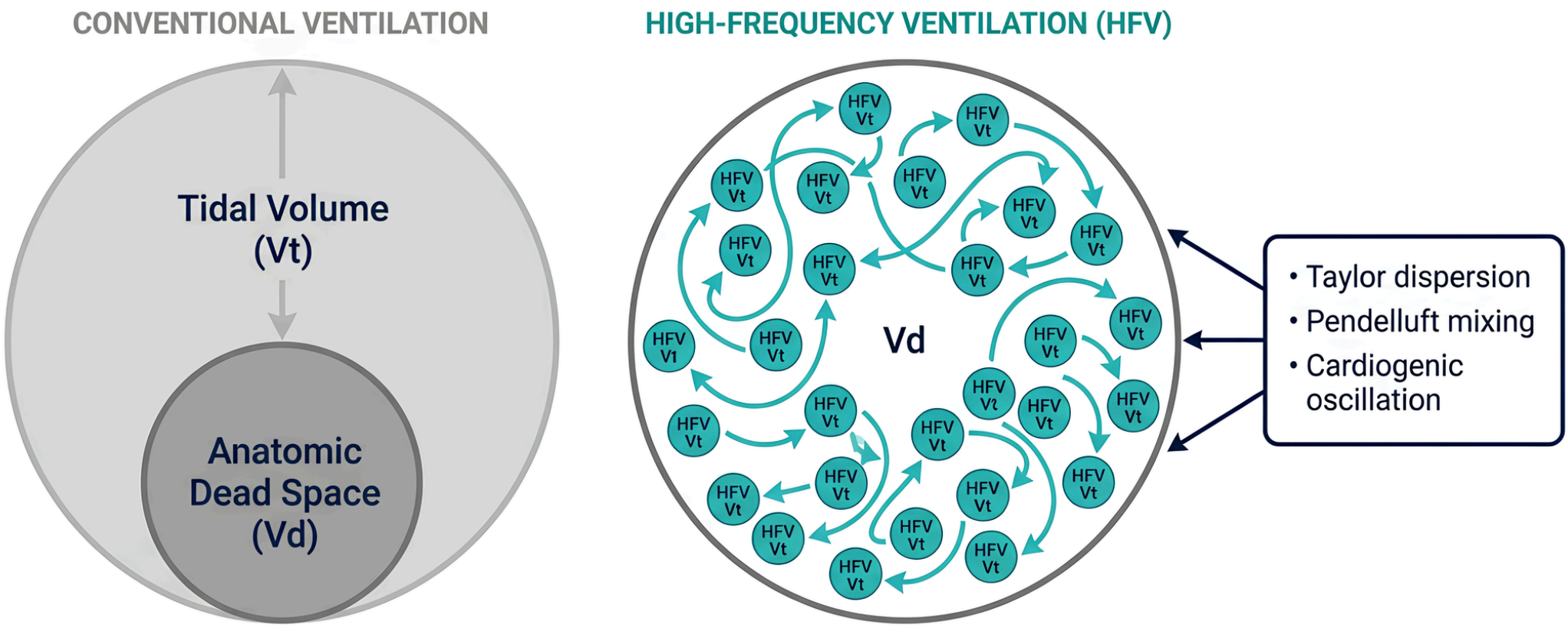
High-Frequency Ventilation in the Neonate Mechanics, Strategies, and Precision Monitoring

Based on Chapter 24: High-Frequency Ventilation by Martin Keszler, J. Jane Pillow, and Sherry E. Courtney in Goldsmith's Assisted Ventilation of the Neonate, 7th Edition.

Breaking the Vt > Vd Paradigm

HFV provides adequate gas exchange even when tidal volumes are significantly smaller than anatomic dead space.



Two Distinct Modalities, One Common Goal

High-Frequency Ventilation (HFV)

High-Frequency Oscillatory Ventilation (HFOV)

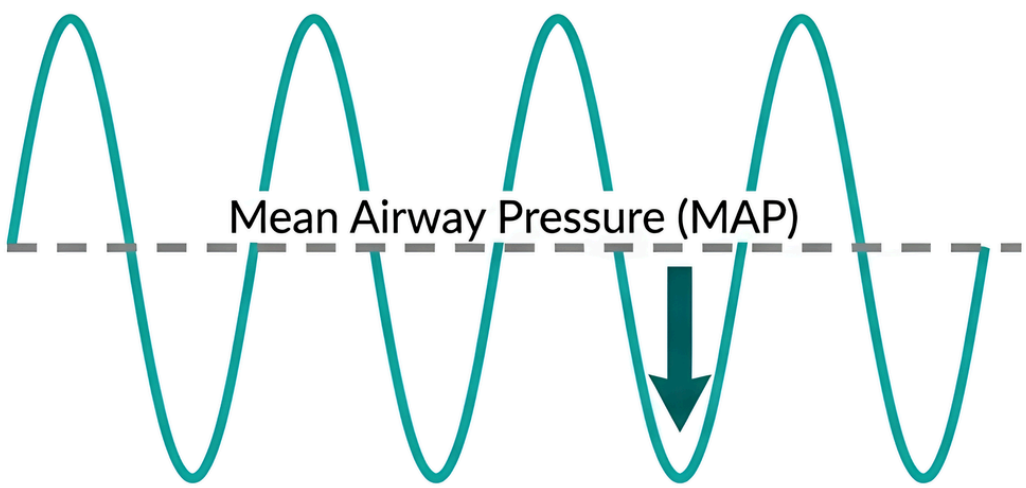
- Focuses on continuous, rapid push-pull cycles.

High-Frequency Jet Ventilation (HFJV)

- Focuses on intermittent, high-velocity gas pulses.

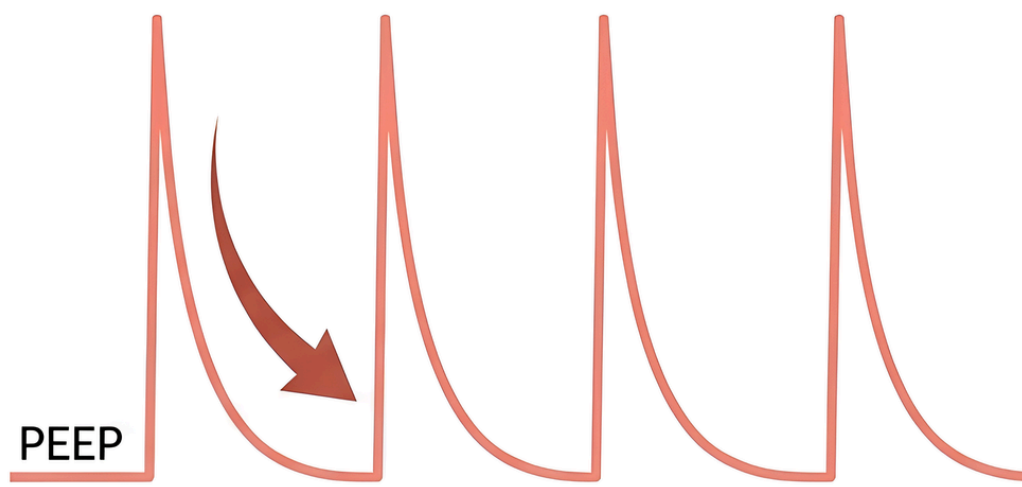
Waveform Mechanics: Push-Pull vs. Pulse-Recoil

Push-Pull (HFOV)



Active Expiration. The ventilator actively pulls gas out of the airway via piston or diaphragm movement.

Pulse-Recoil (HFJV)



Passive Expiration. The lung relies entirely on its own elastic recoil to exhale the gas volume.

The Definitive Clinical Comparison

Parameter	High-Frequency Oscillatory (HFOV)	High-Frequency Jet (HFJV)
Mechanism	Oscillatory pump (piston/diaphragm)	High-velocity gas pulses via special cannula
Expiration	Active (pump pulls gas out)	Passive (lung recoil)
I:E Ratio	Typically 1:1 or 1:2 (fixed %)	Highly variable, ultra-short I-time (e.g., 1:4 to 1:12)
Frequency	5–15 Hz (300–900 breaths/min)	240–600 bpm (4–10 Hz)
Equipment	SensorMedics 3100A, VN500, Fabian	Bunnell LifePulse
Indications	Homogeneous lung disease (RDS), diffuse alveolar disease	Non-homogeneous disease, Air leak syndromes (PIE), MAS

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Tailoring the Strategy to the Pathology

The success of HFV depends entirely on matching your pressure-volume strategy to the underlying lung mechanics.

Homogeneous Disease
(Requires Recruitment)

Air Leaks & Non-Homogeneous
(Requires Healing)

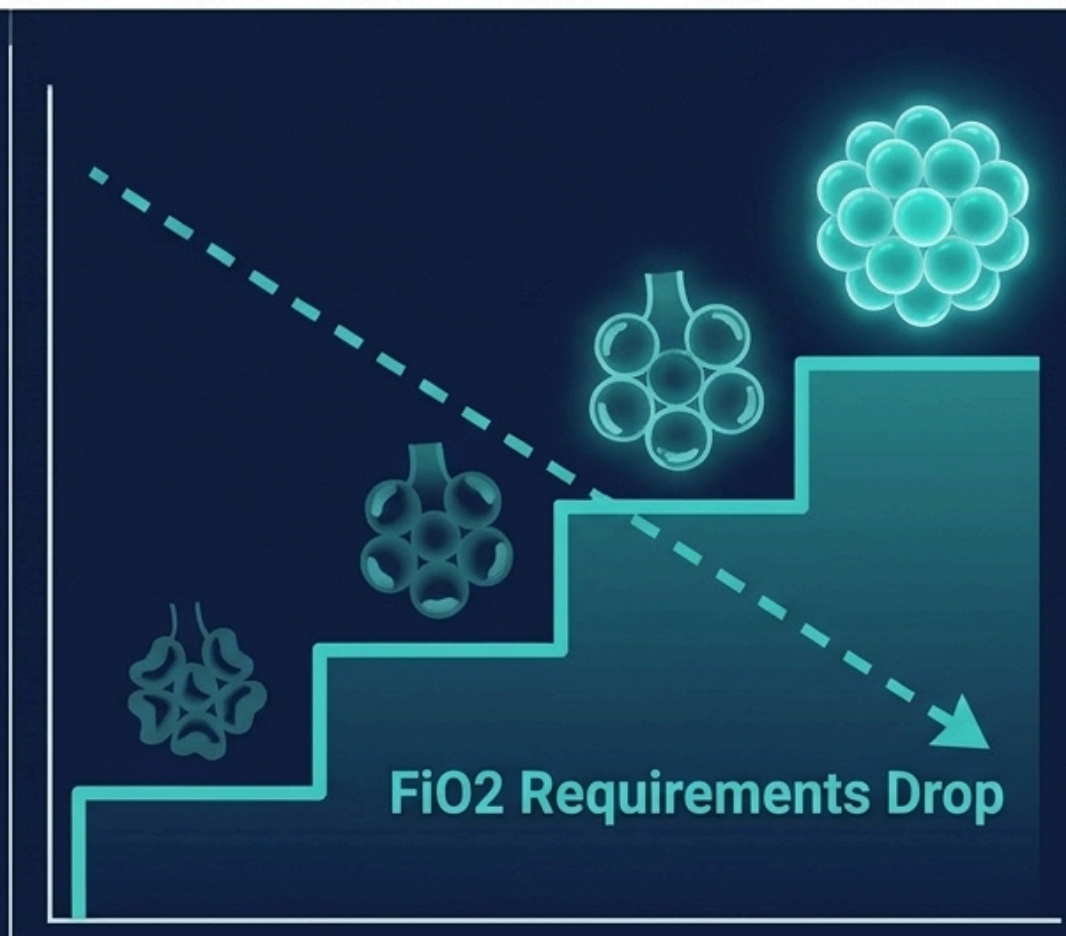


Strategy A: The Open Lung Strategy (High Volume)

Target Pathology: Homogeneous diseases (e.g., pure Respiratory Distress Syndrome).

Clinical Goal: Recruit and maintain optimal lung volume on the deflation limb of the pressure-volume curve.

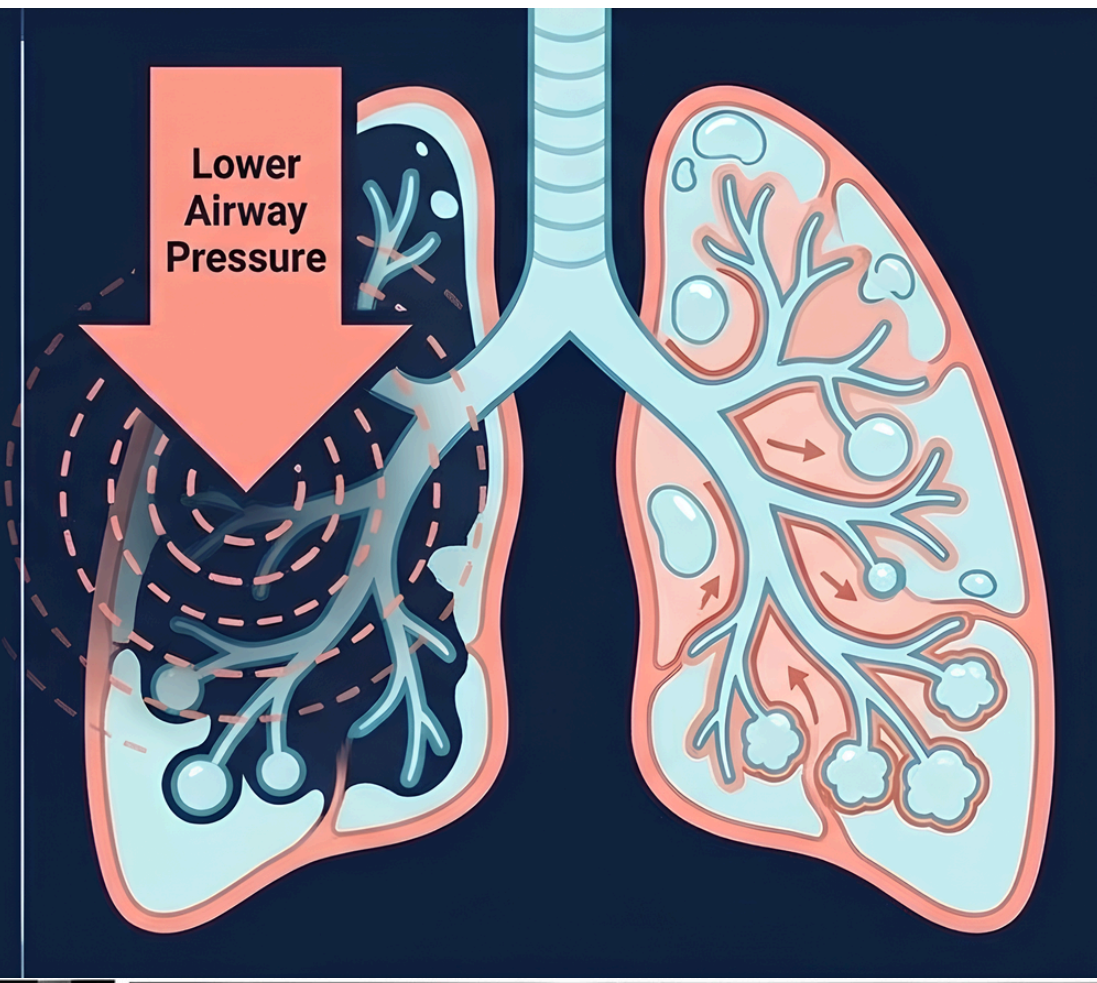
Execution: Incrementally increase Mean Airway Pressure (MAP) to overcome critical opening pressures while closely monitoring oxygenation. Once optimal alveolar expansion is achieved and sustained, aggressively wean FiO2 to prevent toxicity.

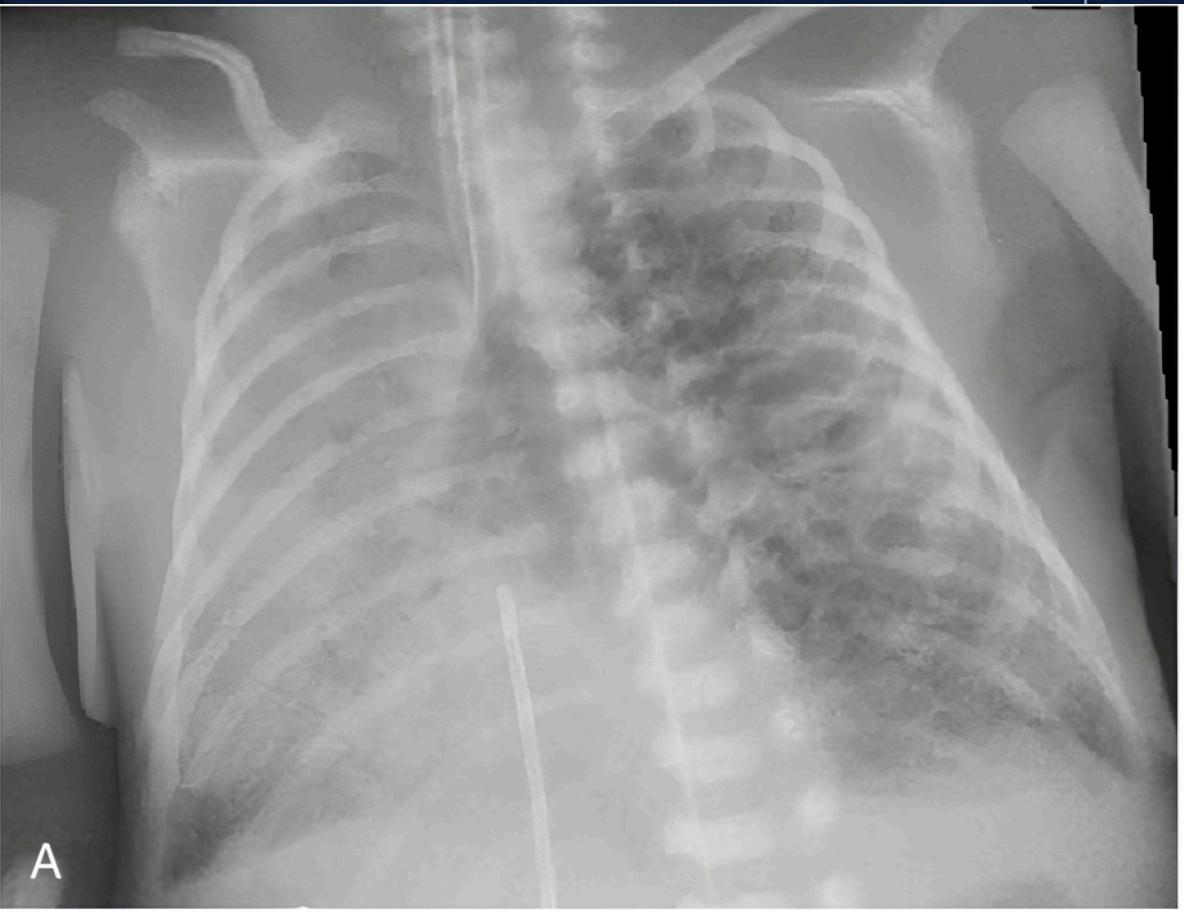


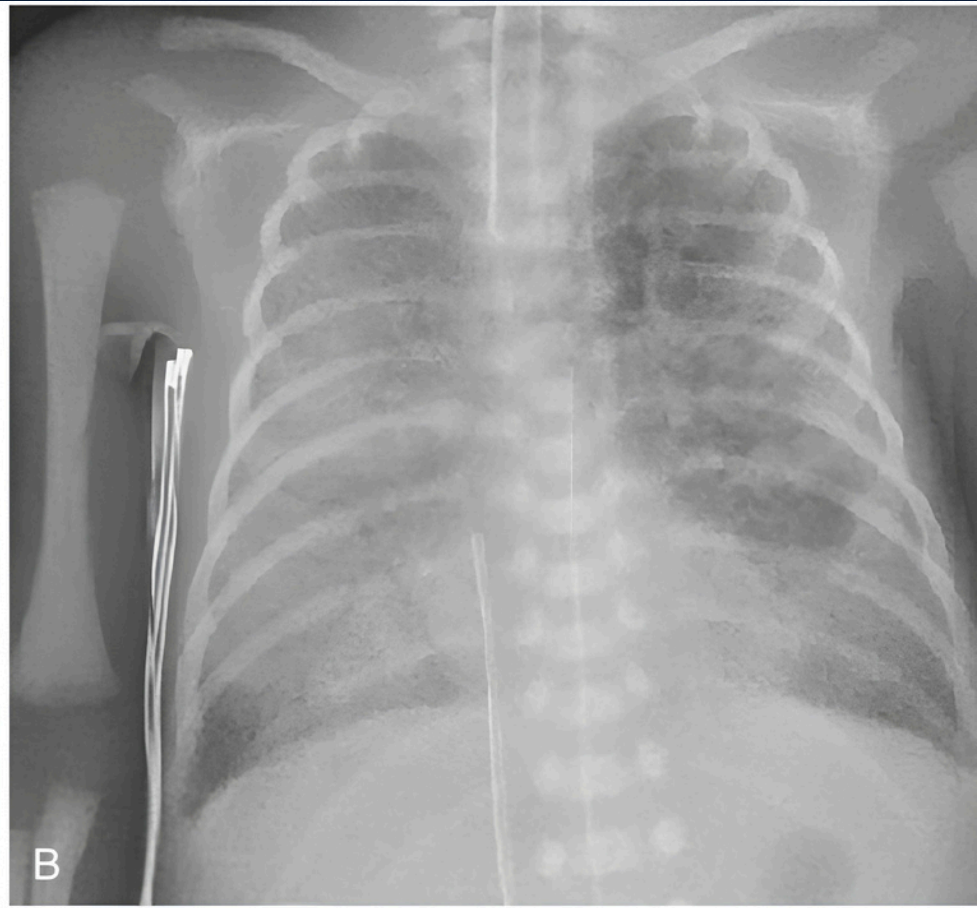
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Strategy B: The Low PEEP Strategy (Low Volume)

Target Pathology: Air leak syndromes (PIE, pneumothorax).
Clinical Goal: Minimize distending pressures to allow anatomical leaks to heal while safely maintaining baseline ventilation.
Execution: Tolerate permissive hypercapnia and accept a higher FiO2 requirement. Deliberately utilize lower MAP/PEEP to avoid driving gas into the interstitium. Highly synergistic with the passive expiratory mechanics of HFJV.







Chest radiograph showing unilateral tension pulmonary interstitial emphysema (PIE) with atelectasis of the right lung and partial herniation of the left lung across the midline (A). Following 12 hours of selective right lung ventilation by aiming the **jet ventilation** stream into the right mainstem bronchus without actual mainstem bronchus intubation, there is improved aeration of the right lung with resolution of tension and substantial resolution of PIE on the left (B).

Radiographic Targets: The Gold Standard for Volume

< 8 ribs: Persistent atelectasis and failed recruitment.



Target: 8.5 to 9 rib expansion.

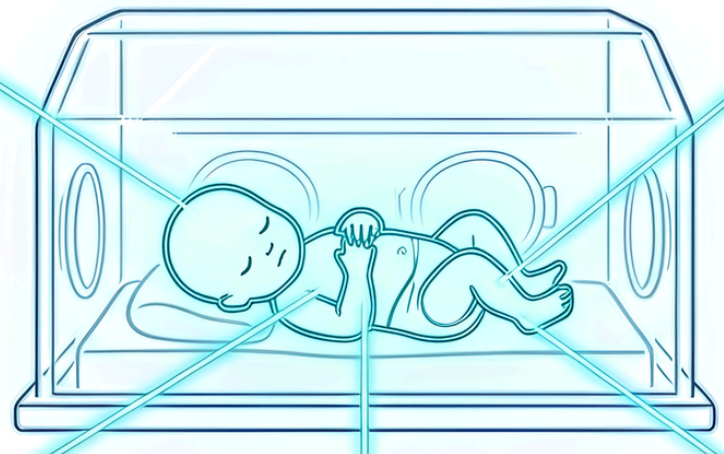


CLINICAL WARNINGS:

> 9 ribs: Severe over-distension, risking collapsed pulmonary capillaries and decreased venous return to the heart.

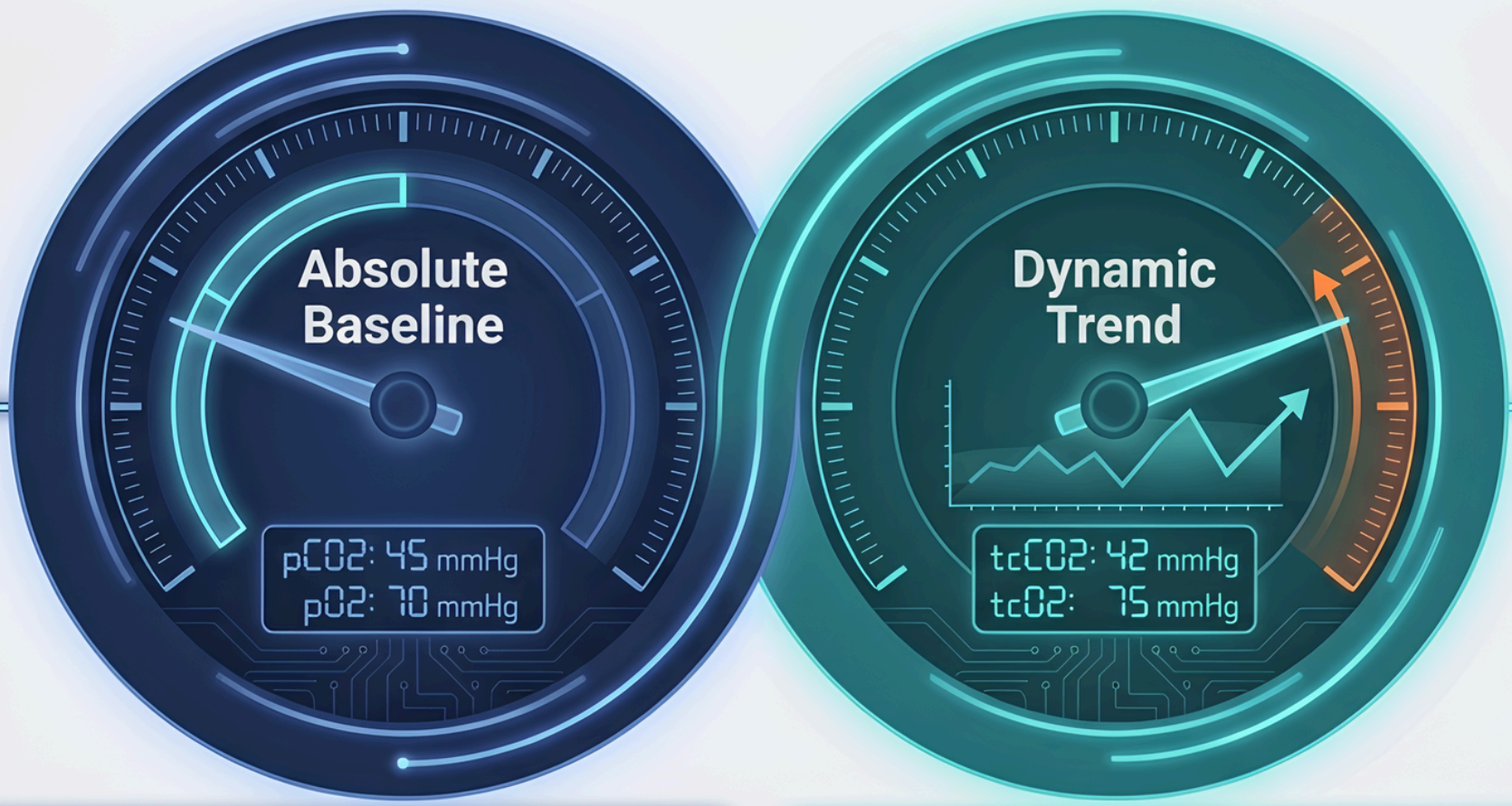
Precision Medicine Requires Precision Monitoring

Managing High-Frequency Ventilation with standard conventional monitoring is flying blind. Real-time, multimodal feedback loops are non-negotiable.



- Radiography (CXR)
- Arterial Blood Gas (ABG)
- Echocardiography
- Transcutaneous (tcO_2/$tcCO_2$)
- Electrical Impedance Tomography (EIT)

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ABG (Arterial Blood Gas): The absolute anchor.
Essential for establishing baseline pCO2 and pO2 targets.
Directly drives mechanical adjustments to amplitude (ventilation/CO2 clearance) and MAP (oxygenation).

Transcutaneous Monitoring (tcCO2/tcO2): The early warning system.
Because gas exchange shifts can occur extraordinarily rapidly on HFV, continuous transcutaneous trend analysis is critical to catch hyper/hypocapnia long before the next scheduled blood draw.



Echocardiography:
Vital for assessing right ventricular function and monitoring for pulmonary hypertension.
Acts as the primary safety check to ensure high MAP is not critically compromising venous return or cardiac output.

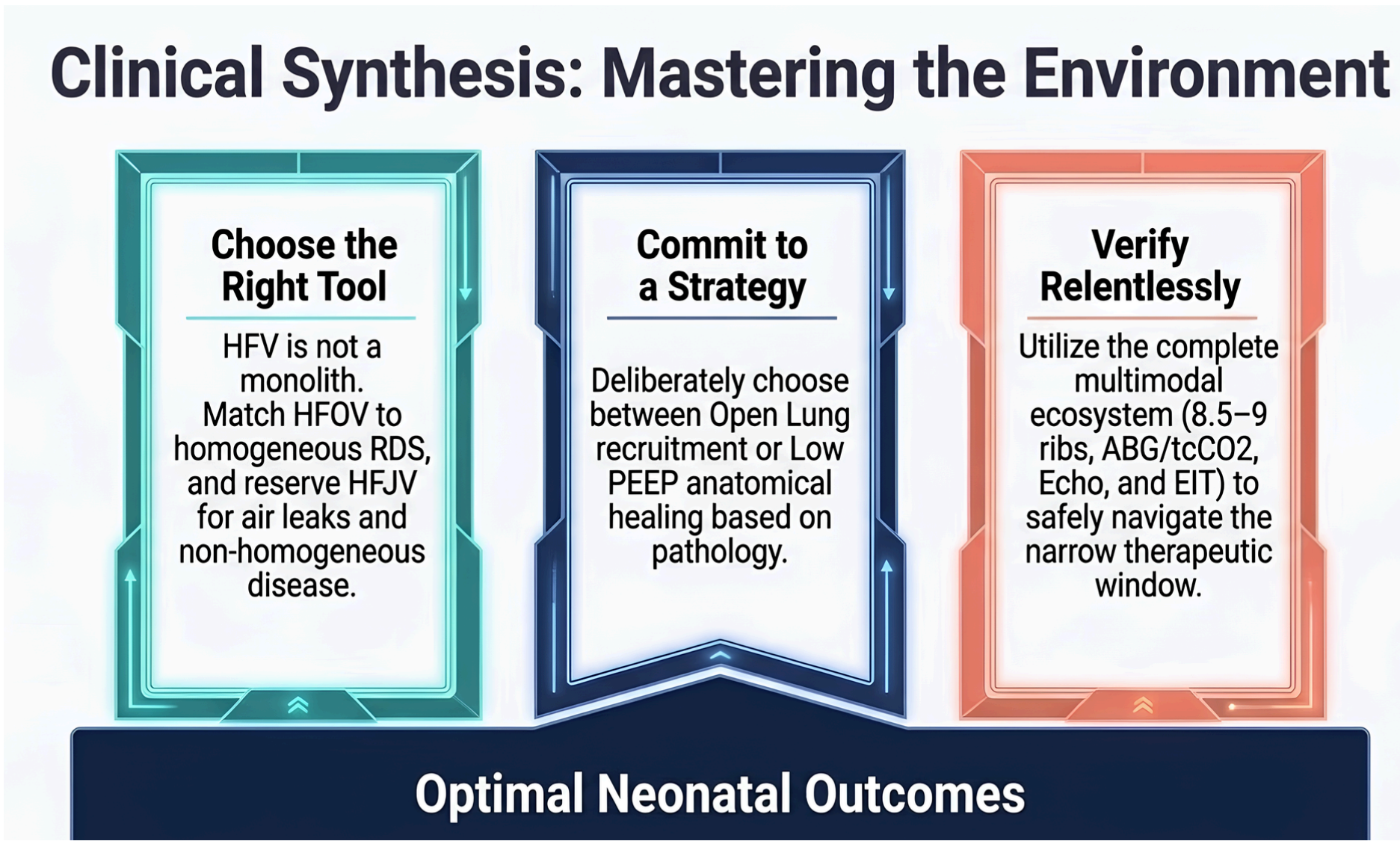
Electrical Impedance Tomography (EIT):
An emerging, radiation-free bedside tool.
Allows for continuous, real-time visualization of regional lung aeration and ventilation distribution without repeated X-ray exposure.



Basic Weaning Strategies With Pressure-Controlled Modes and High-Frequency Ventilation

Desired Result	Action: SIMV	Action: AC or PSV	Action: HFV
Increase Pco_2	Reduce PIP, rate	Reduce PIP	Reduce Amplitude
Decrease Po_2	Reduce FiO_2, PEEP	Reduce FiO_2, PEEP	Reduce FiO_2, MAP

AC, Assist control; *FiO_2*, fractional inspired oxygen concentration; *HFV*, high-frequency ventilation; *MAP*, mean airway pressure; *PEEP*, positive end-expiratory pressure; *PIP*, peak inflation pressure; *PSV*, pressure-support ventilation; *SIMV*, synchronized intermittent mandatory ventilation.



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Ventilatory Settings at Which Extubation Should Be Considered in Infants 2 Weeks of Age and Under

Conventional Ventilation (AC, SIMV, PSV)

- **SIMV: PIP ≤16 cm H_2O, PEEP ≤6 cm H_2O, rate ≤20, FiO2 ≤0.30**

AC/PSV, BW <1000 g: MAP ≤7 cm H2O and FiO2 ≤0.30

AC/PSV, BW >1000 g: MAP ≤8 cm H2O and FiO2 ≤0.30

Volume-Targeted Ventilation (Tidal Volume Measured at the Endotracheal Tube)

- Tidal volume ≤4.0–4.5 mL/kg (5–6 mL/kg if <700 g or >2 weeks of age) and FiO_2 ≤0.30

High-Frequency Oscillatory Ventilation

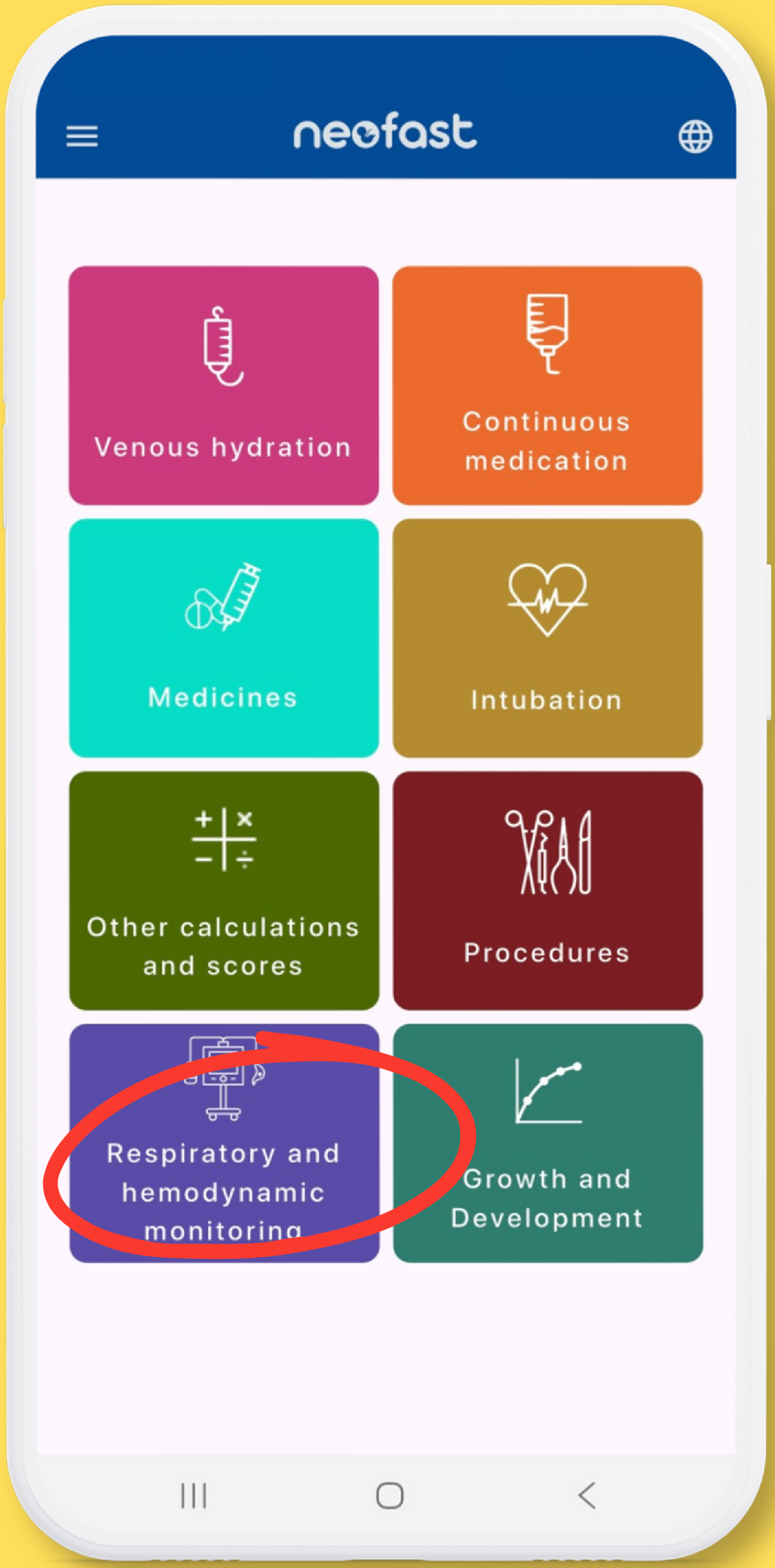
- BW <1000 g: MAP ≤7 cm H_2O and FiO_2 ≤0.30
- BW >1000 g: MAP ≤9 cm H_2O and FiO_2 ≤0.30

High-Frequency Jet Ventilation

- BW <1000 g: PIP ≤14 cm H_2O, MAP ≤7 cm H_2O, and FiO_2 ≤0.30
- BW >1000 g: PIP ≤16 cm H_2O, MAP ≤8 cm H_2O, and FiO_2 ≤0.30

Older infants may be able to be extubated from higher pressures or tidal volumes. Extubation should only be performed if the patient does not have significant tachypnea or increased work of breathing.

AC, Assist control; *BW*, birth weight; *MAP*, mean airway pressure; *FiO_2*, fractional inspired oxygen concentration; *PEEP*, positive end-expiratory pressure; *PIP*, peak inflation pressure; *PSV*, pressure-support ventilation; *SIMV*, synchronized intermittent mandatory ventilation.



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