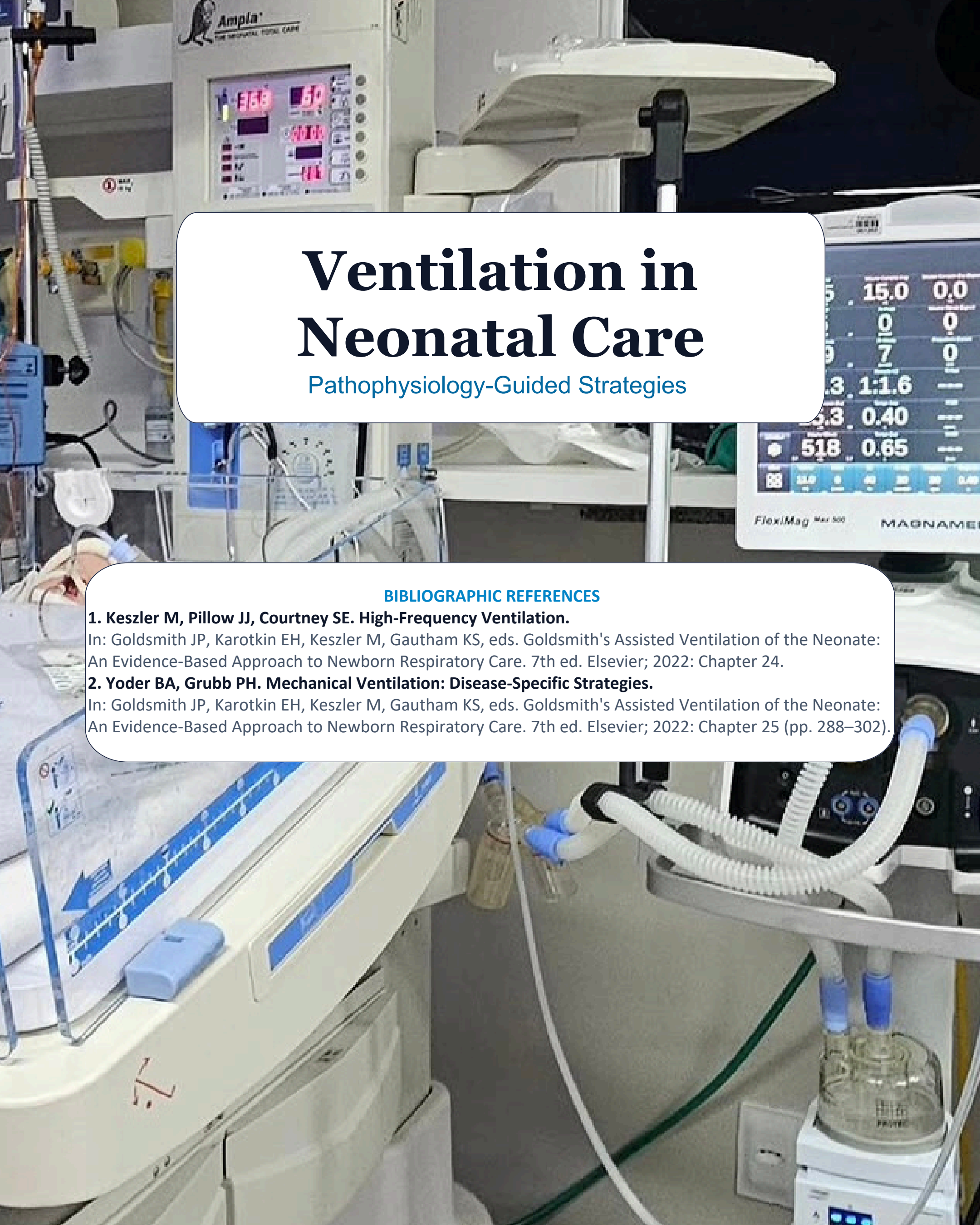




Ventilation in Neonatal Care

Pathophysiology-Guided Strategies

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Respiratory Distress Syndrome (RDS)

Pathophysiology & Mechanical Strategy

Surfactant deficiency, low lung compliance, and diffuse microatelectasis. Primary goals: Early CPAP/surfactant. If intubated, establish Open Lung Strategy via HFOV or Volume-Targeted Conventional Ventilation (SIMV-VG) to avoid volutrauma and atelectrauma.

Ventilator Mode	BW < 1000g	BW 1000–2000g	BW > 2000g	Key Adjustments / Goals
HFOV Initial MAP	8–10 cmH2O	10–12 cmH2O	11–13 cmH2O	Set 1–2 cmH2O above conventional MAP; titrate by 1–2 for recruitment.
HFOV Amplitude (Delta P)	18–22 cmH2O	20–25 cmH2O	22–28 cmH2O	Adjust for gentle chest wiggle; controls CO2 clearance.
HFOV Frequency (Hz)	12–15 Hz	10–12 Hz	8–10 Hz	I:E ratio fixed at 1:2 (33% Ti). Higher Hz = smaller Vt.
SIMV-VG Conventional	Vt: 4.0–6.0 mL/kg PEEP: 5–6 cmH2O	Vt: 4.0–6.0 mL/kg PEEP: 5–6 cmH2O	Vt: 4.0–6.0 mL/kg PEEP: 5–6 cmH2O	Rate: 30–50 bpm; Ti: 0.30–0.35 s. Wean PIP as compliance improves.

Meconium Aspiration Syndrome (MAS)

Pathophysiologic Spectrum & Ventilator Selection

MAS presents with heterogeneous pathology: airway obstruction (ball-valve effect, air trapping), surfactant inactivation, chemical pneumonitis, and severe PPHN. Ventilator mode must match the dominant pathophysiologic feature.

Ventilator Mode	Airway Obstruction / Air Trapping	Parenchymal Disease (Low Vol)	Pulmonary Hypertension (PPHN)
Conventional (SIMV-VG)	• Vt: 5.0–6.0 mL/kg • PEEP: 4–5 cmH2O (low to prevent trapping) • Rate: 30–40 bpm; Short Ti (0.30s)	• Vt: 5.0–6.0 mL/kg • PEEP: 5–8 cmH2O (recruitment) • Rate: 30–50 bpm	• Optimize lung volume • Avoid hypercarbia/acidosi s • Target SpO2 92–98%
HFJV (Jet)	• Rate: 240–360 cpm (low Hz) • Short Ti: 0.02 s (long Te) • PEEP: 4–5 cmH2O (prevents air trapping)	• PEEP: needed for 8–9 rib expansion • PIP: adjust for chest wiggle	• Combine with iNO if unresponsive • Maintain systemic vascular pressure
HFOV (Oscillator)	• Lower frequency: 6 Hz • Low MAP to allow expiration • Larger Delta P if needed	• Higher MAP for recruitment • Frequency: 6–8 Hz • Delta P for chest wiggle	• Recruitment to optimal FRC • Avoid overdistension (impedes RV)

Congenital Diaphragmatic Hernia (CDH) & Hypoplasia

Pathophysiology & Gentle Ventilation Principles

Pulmonary hypoplasia (reduced bronchial generations and alveoli) combined with pulmonary vascular hyper-reactivity and severe PPHN. Priority: Gentle Ventilation Strategy to avoid barotrauma and overdistension in the fragile hypoplastic lung.

Parameter	HFOV (Oscillator)	HFJV (Jet)	SIMV / VG (Conventional)
Pressure Settings	MAP: 12–17 cmH2O (rarely > 16–17) Delta P: 24–35 cmH2O	PIP: 25–35 cmH2O PEEP: 6–10 cmH2O (rarely > 10)	PIP: 16–25 cmH2O PEEP: 4–6 cmH2O
Frequency & Timing	Frequency: 8–10 Hz I:E Ratio: 1:2 (33% Ti)	Frequency: 360–420 cpm (6–7 Hz) Ti: 0.02 s	Rate: 45–60 bpm Ti: 0.30–0.35 s
Target Tidal Volume (Vt)	Target low Vt via High Hz Avoid overdistension	Low Vt delivered at jet tip Minimal dead space ventilation	Vt: 4.0–5.5 mL/kg (Low Vt strategy)
Gasometric & CXR Goals	- Target CXR Expansion: 8.5–9 posterior ribs - Pre-ductal SpO2: > 85% (1st hr) -> 88–98% post-stab - PaCO2 Target: 45–65 mmHg (Permissive Hypercapnia)		

Severe / Chronic Bronchopulmonary Dysplasia (BPD)

Pathophysiology & Chronic Mechanical Management

Characterized by high airway resistance, long and heterogeneous time constants, airway malacia/collapsibility, and severe air trapping. Requires low respiratory rates, prolonged inspiratory times, and high PEEP to stent open malacic airways.

Ventilator Parameter	Mild / Moderate BPD	Severe / Chronic BPD (Late Stage)
Tidal Volume (Vt)	5.0–8.0 mL/kg	6.0–12.0 mL/kg (May require 2–3 mL/kg added circuit dead space)
PEEP Setting	5.0–8.0 cmH2O	8.0–14.0 cmH2O (High PEEP required to stent malacic airways and prevent collapse)
Respiratory Rate & Ti	Rate: 20–40 bpm Ti: 0.35–0.45 s	Rate: 11–30 bpm (Low rate allows long Te for expiration) Ti: 0.5–1.0 s (Long Ti for high resistance)
Clinical Goals & Targets	SpO2: 92–95% PaCO2: 45–55 mmHg	SpO2: 92–98% PaCO2: 50–65 mmHg (Accept compensated respiratory acidosis)

Comparative Analysis: HFOV vs. HFJV

Parameter / Feature	HFOV (High-Frequency Oscillatory Ventilation)	HFJV (High-Frequency Jet Ventilation)
Mechanism of Action	Piston, diaphragm, or linear motor generating continuous sinusoidal pressure oscillations around a constant MAP.	Short high-velocity gas pulses delivered to upper airway via dedicated jet injector or specialized ETT adapter.
Expiratory Phase	ACTIVE expiration: piston/diaphragm actively pulls gas back during the expiratory phase.	PASSIVE expiration: depends on natural elastic recoil of lungs and chest wall.
Frequency & I:E Ratio	Frequency: 3–15 Hz (180–900 cpm). I:E Ratio: Usually fixed at 1:2 (33% Ti) or 33–50%.	Frequency: 240–660 cpm (4–11 Hz, typ. 420 cpm). Short Ti (0.02 s / 20 ms), low I:E (1:4.8 to 1:12).
Primary Controls	Oxygenation: MAP and FiO2. Ventilation (CO2): Amplitude (Delta P) and Frequency (Hz).	Oxygenation: PEEP/MAP (via tandem conventional vent). Ventilation (CO2): Servo/Drive pressure (PIP) and rate (cpm).
Clinical Indications	Diffuse homogeneous lung disease, RDS recruitment, CDH, pulmonary hypoplasia.	Air leak syndromes (PIE, pneumothorax), focal obstruction, MAS with severe air trapping.

Lung Protection Strategies in Critical Neonates



Open Lung Strategy (HFOV)

- **Stepwise Recruitment:**

Increase MAP in 1–2 cmH₂O increments while monitoring SpO₂/FiO₂ to open collapsed alveoli and establish optimal FRC.

- **Closing Pressure Identification:**

Once recruited (low FiO₂ ≤ 0.30), gradually reduce MAP until de-recruitment occurs (SpO₂ drop or FiO₂ increase).

- **Optimal MAP Setting:**

Set final operational MAP 1–2 cmH₂O ABOVE the closing pressure on the inflation limb of the hysteresis curve.

- **Ventilation Control:**

Adjust Amplitude (Delta P) to achieve visible gentle chest wiggle without overdistension.



Low PEEP / Air Leak Strategy (HFJV)

- **Air Leak Indication:**

Targeted strategy for Pulmonary Interstitial Emphysema (PIE) and pneumothorax to minimize gas trapping.

- **Low PEEP Concept:**

Maintain PEEP at low-to-conventional levels (4–5 cmH₂O) to avoid stoking tissue air leaks.

- **Prolonged Expiratory Time:**

Short T_i (0.02 s) with long T_e allows complete alveolar emptying, preventing dynamic hyperinflation.

- **Healing Permissive Environment:**

Reduces peak airway pressure exposure, facilitating decompression and healing of parenchymal tears.

Monitoring Protocol

Arterial Blood Gas (ABG) & Transcutaneous

Continuously monitors PaCO₂ and PaO₂ via tcPCO₂ and SpO₂. Crucial during HFV because small adjustments in Amplitude or Hz cause massive changes in CO₂ clearance, preventing severe hypocapnia.



Chest Radiography (CXR)

Assesses lung volume expansion (Target: 8.5–9 posterior ribs above diaphragm). Confirms ETT placement above carina (T2–T3) and detects complications like pneumothorax or PIE.



Echocardiography

Evaluates cardiac hemodynamic impact (high MAP impeding venous return / cardiac output) and monitors PPHN severity, RV pressures, and ductal shunting.

Electrical Impedance Tomography (EIT)

Advanced bedside non-invasive tool to monitor real-time regional lung volume changes, heterogeneity, and ventilation distribution during recruitment maneuvers.

“The most important factor associated with safe and successful ventilator management of the sick neonate is the **person operating the ventilator rather than the ventilator itself.”**
— Goldsmith's Assisted Ventilation of the Neonate (7th Edition).

“Our primary goal is to **ensure the safety of the newborn.”**
— The NeoFast Family.

