

HFJV Management

*East Bay Newborn Specialists Guideline
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General

- HFJV is time-cycled, pressure-limited HFV with passive exhalation from elastic recoil
- A conventional ventilator is run in tandem with HFJV to generate PEEP and sigh breaths

Indications for HFJV

- HFJV is indicated for management of patients with PIE or broncho-pleural fistula. The short T_{insp} of HFJV minimizes air leak and promotes healing of the PIE or BP fistula
- HFJV can be used effectively for any restrictive disease (e.g. RDS, pneumonia)
- HFJV provides excellent ventilation in patients with pulmonary hypoplasia
- HFJV may be superior to HFOV or conventional ventilation in some patients with chronic lung disease and air trapping

Differences between HFOV and HFJV:

HFOV:

- Active exhalation
- % cycle (33%)
- Fixed I:E (1:2)
- VT dependent on rate (Hz)

HFJV:

- Passive exhalation
- Set inspiratory time (.02 sec), which rarely is adjusted
- Variable I:E
- VT ($\Delta P_{PIP-PEEP}$) independent of rate

Patients with gas trapping, PIE, or air leaks will benefit from a long expiratory time:

- With HFOV, lowering the Hz will allow a longer expiratory time, but the inspiratory time will be longer. The tidal volume of each breath will therefore be increased which may be a disadvantage in the setting of gas trapping. With HFOV, the I:E ratio stays 1:2 no matter if you reduce the Hz. The difference is the I time is a % of the cycle time.
- With HFJV, we can use extremely small tidal volumes (< dead space) with long exhalation times. Because the I-time is usually fixed (0.02 sec), you can adjust the rate and deliver different I: E ratios.

HFJV Oxygenation:

MAP
Set PEEP for appropriate MAP
"Sigh" breaths for lung recruitment

Ventilation:

$\Delta P_{PIP-PEEP}$
HFJV PIP
HFJV rate

Initial HFJV settings:

- HFJV rate traditionally have started at 420 breaths per min. Use lower rates, e.g., 240-360 breaths/min (4-7 Hz) in the setting of ELBW premature infants or those with PIE, pneumothorax, or hyperinflation. HFJV can be used as the initial primary mode of ventilation for premature infants with RDS
- Lowering the rate increases the expiratory time:
 - Rate I:E
 - 420 1:6
 - 360 1:7
 - 300 1:9
 - 240 1:12

Initial HFJV Settings for RDS to prevent air trapping, hyperinflation, and hypocarbia:

- < 24 weeks GA or < 600 gms: 300 BPM
- 24-26 weeks GA or 600-1000 gms: 360 BPM
- \geq 27 weeks GA or \geq 1000 gms: 420 BPM

- If PIE begins to develop drop rate from 360 to 300. Below rates of 300, changes can be made by 20 BPM for fine tuning
- Begin PEEP @ 5 cm to avoid hyperinflation, can increase as needed if still poorly aerated and requiring FiO₂ > 0.40 after surfactant therapy. Aim for 9 ribs inflation
- Begin PIP @ 22-24 cm with visible chest vibrations and adjust based on pCO₂ goals
- HFJV I-time 0.02 sec to minimize risk of air trapping

Initial HFJV Settings for babies \geq 27 weeks:

- **Maintaining adequate PEEP is important for success with HFJV.** Begin with HFJV PEEP 6-12. Initial PEEP should be 3 cm below the MAP on either CMV or HFOV. After converting to HFJV, the MAP on the Jet should equal the MAP on either CMV or HFOV prior to conversion. If necessary for oxygenation, stop at a MAP 1 cm higher. If starting immediately on HFJV, use a PEEP of 8 and then titrate based on x-ray findings and oxygenation.
- Begin HFJV PIP at 24 cm with visible chest vibrations and adjust based on pCO₂ goals
- HFJV I-time 0.02 sec

Adjusting conventional ventilator sigh breath settings using the Servo-U:

- Provide PEEP to achieve desired MAP; generally, PEEP is set at 6-12, depending on patient and dx
- Provide lung recruitment sigh breaths to prevent atelectasis
- Use the SIMV PC + PS mode. Set conventional rate beginning with 4 breaths/min during recruitment phase. Decrease rate to 2 once peep is optimized. The minimum rate allowable using the Servo-U is 1.
- Set PC above PEEP. PIP = PEEP + 6 cm H₂O (minimal adequate PIP)
- Set PS above PEEP to 0
- Conventional inspiratory time (T_{insp}) 0.3-0.5 sec; longer for poor compliance and shorter for PIE. For standard settings, begin with 0.4 sec

Understanding Servo Pressure:

- Servo Pressure = driving pressure that provides flow
- Servo pressure changes as lung volume changes
- As lung volume increases, Servo pressure increases (improved compliance and/or resistance, increased air leak, tubing leaks)
- As lung volume decreases, Servo pressure decreases (reduced compliance and/or resistance, tension pneumothorax, right mainstem intubation, airway secretions)
- When increasing HFJV PIP to improve ventilation, expect an increase in the Servo Pressure by 0.3

Adjusting HFJV settings based on lung inflation:

- CXR is not a particularly good measure of lung inflation. However, it can provide a crude estimate of significant over- or under-inflation. Aim for 9 rib expansion
- Ventilator settings which can contribute to over-inflation include air trapping (frequency is too high), excess PIP, excess PEEP
- Ventilator settings which can contribute to under-inflation are primarily those which contribute to inadequate mean airway pressure – PEEP and HFJV PIP

Adjusting HFJV settings based on FIO₂:

As in conventional ventilation, oxygenation is primarily dependent on mean airway pressure, and mean airway pressure is primarily dependent on PEEP and HFJV PIP

- Assuming acceptable lung inflation, adjust Paw based on FIO₂
 - FIO₂ > 0.40, increase PEEP by 10% increments until FIO₂ no longer decreases – remember to increase HFJV PIP as needed to maintain adequate delta P for ventilation. If increased PEEP interferes with cardiac output, you may need to lower PEEP and increase backup IMV on conventional ventilator to 5 bpm
 - FIO₂ < 0.3, decrease PEEP by 10% increments until FIO₂ increases, or until mPaw low enough to extubate – remember to decrease HFJV PIP as needed to maintain appropriate delta P for ventilation
- If FIO₂ changes by 0.2, repeat a CXR to evaluate lung inflation

Adjusting settings based on PaCO₂:

- ΔP (PIP-PEEP) creates V_T . Adjust HFJV PIP to provide adequate ventilation.
- Be aware that decreasing PIP reduces overall Paw which may lead to atelectasis and increased FiO₂ requirement. Do not make more than 1-2 HFJV PIP changes without considering a reciprocal change in PEEP to maintain mPaw.
- Remember, this is high frequency PIP with significant attenuation of the applied Delta P. For patients with high airways resistance and poor compliance (severe BPD), jet PIPs may be increased into the 30-40s to decrease pCO₂ if needed.

- To change PaCO₂ ± 2 - 4 mm Hg adjust PIP by 1-2 cm H₂O
- To change PaCO₂ ± 5 - 9 mm Hg adjust PIP by 3-4 cm H₂O
- To change PaCO₂ ± 10 - 14 mm Hg adjust PIP by 5-6 cm H₂O
- Always check a blood gas 15-20 minutes after any change in PIP and/or monitor TCpCO₂

- When making adjustments in HFJV PIP to improve ventilation, expect an increase in the Servo Pressure by 0.3

Adjusting HFJV settings for worsening BPD:

Consider increasing HFJV rate as needed from 360 to 420 to improve lung recruitment
Consider increasing Sigh breath rate from 4 to 8 and IT from 0.4 to 0.5

Weaning and extubation to CPAP:

- Reduce HFJV PIP
- Reduce HFJV Rate to encourage spontaneous breathing

Extubation Criteria to nCPAP:

RDS:

- MAP < 8
- Delta P < 10-12
- FiO₂ < 35%

BPD:

- MAP < 10-12
- Delta P < 14-16
- FiO₂ < 50%

Begin with nCPAP level ~ 2cm > PEEP

Management Strategies:

- **Oxygenation Inadequate** - If below optimal lung volume and if FiO₂ 0.6 - 0.7 or more, increase PEEP by 1 - 2 cm H₂O. If FiO₂ is 1.0, increase by 2 - 4 cm H₂O. When increasing PEEP, also increase the PIP by the same amount to keep tidal volume constant. **Can also increase the PIP, IT or rate of the sigh breaths to improve alveolar recruitment.**
- **Oxygenation Inadequate and CO₂ Adequate** - If CO₂ is acceptable but not oxygenating, increase MAP but **keep TV or delta P constant**. Thus, when increasing PEEP, also increase the PIP by the same amount (1 and 1 cm H₂O or 2 and 2 cm H₂O for both PIP and PEEP).
- **Oxygenation Inadequate and CO₂ Too Low** – Increase PEEP (1-2 cm) but keep PIP constant. This increases MAP, while decreasing the delta P, thus improving oxygenation while decreasing the TV.
- **Oxygenation Inadequate and CO₂ Too High** – Increase both MAP and delta P by increasing PIP until CO₂ is acceptable. If the oxygenation is still inadequate with an acceptable CO₂, then increase both PIP and PEEP by the same amount to keep TV constant.
- **Oxygenation Too Good and CO₂ Too Low** – Decrease PIP until CO₂ is appropriate. If oxygenation is still too good with an over-inflated chest X-ray, start decreasing both PIP and PEEP by the same amount to decrease MAP while keeping a constant delta P.

- **Oxygenation Adequate and CO2 Too Low** – Wean **delta P** by decreasing PIP but increase PEEP as necessary to keep MAP constant. This decreases TV but keeps MAP constant, thus preventing atelectasis with loss of oxygenation.
- **Oxygenation Too Good and CO2 Adequate** — If CO2 is acceptable but FiO2 is too low or CXR over-inflated, then wean MAP by keeping TV (delta P) constant by decreasing both PIP and PEEP by the same amount (1 and 1 cm H2O or 2 and 2 cm H2O).
- **Warning:** Oxygenation is directly proportional to PEEP (MAP) unless lung is over-inflated. If the lung is over-inflated, may need to decrease PEEP to improve oxygenation and ventilation.

Bunnell Support services:

24 hr Bunnell Clinical/Technical Hotline: 800-800-4358

Clinical Specialist: Keith Kohutek keithmk@bunl.com

Bunnell Instruction Video: <https://bunl-my.sharepoint.com/:v/p/keithmk/EfAJiHHwN1ZNk1UBSuNzA1BhlcR2WZHDmvs5qo9qgi9IA?e=vW2vxA>

References:

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<https://uichildrens.org/sites/default/files/jetventilation2.pdf>

https://www.healthcare.uiowa.edu/marcom/uichildrens/neonatology-handbook/high-frequency-jet-ventilator-table.pdf?_ga=2.21354555.1216093937.1617646370-493737277.1616609811

Dr. Jonathan Klein presentation at Cool Topics 2021: Respiratory Management from Birth to Discharge of the Periviable Infant at 22 to 23 weeks Gestation: First Intention High Frequency Jet Ventilation