Pocket guide

3100A High Frequency Oscillatory Ventilator

CareFusion

This clinician's guide describes equipment set-up and patient management guidelines for the 3100A High Frequency Oscillatory Ventilator (HFOV).

Warning

Do not use this pocket guide as a substitute for *(1)* reading and understanding the operator's manual, *(2)* being properly trained or *(3)* having competency using the CareFusion 3100A High Frequency Oscillatory Ventilator.

Use this document as a guideline for initiating and managing a patient on HFOV. Management of a patient on the 3100A HFOV must be altered based on the patient's individual clinical needs. This document is not intended to be used as a substitute for clinical experience or medical guidance.

Table of contents

Indications and contraindications

Indications

The CareFusion 3100A High Frequency Oscillatory Ventilator (HFOV) is indicated for ventilatory support and treatment of respiratory failure and barotrauma in neonates. The specific patient conditions the HFOV is intended to treat are respiratory distress syndrome (RDS), respiratory failure caused by pulmonary interstitial emphysema (PIE) or air leak (AL).

The CareFusion 3100A HFOV is also indicated for use in the ventilatory support and treatment of selected pediatric patients who, in the opinion of their physician, are failing on conventional ventilation. Patient size and other factors are important when selecting patients to be treated with this ventilator.

Contraindications

The CareFusion 3100A High Frequency Oscillatory Ventilator has no specific contraindications.

Important considerations before placing a patient on HFOV

Hemodynamic status: The patient should be hemodynamically stable—if not, consider optimization of hemodynamic status prior to HFOV initiation.

- Obtain arterial blood gas (ABG).
- Patient's sedation status:
  - On large pediatric patients, consider sedation and neuromuscular blockades for transition.
  - Due to the device's fixed bias flow, patients may be unable to actively breathe and maintain a stable airway pressure and lung volume.
  - Once transitioned, patients may be able to be maintained on sedation only.
  - Neonates and infants may only require sedation.
- Ensure the patient has had a recent chest x-ray.
- Verify whether the patient requires an off-unit procedure (*e.g., CT scan, MRI)*; if this is the case, consider doing the off-unit procedure before placing the patient on HFOV.
- Suction the patient's airway before placing on HFOV; once stabilized on HFOV, an in-line suction catheter may be used to facilitate secretion removal with minimal lung volume loss.
- Give a brief explanation of HFOV to the family and patient to prepare them for the different sounds, chest wiggle and other differences.

Pre-use checklist review

1. Connect the source gases to system.
2. Connect the power to the system.
3. Check that patient circuit support is installed on the system.
4. Connect the patient circuit and humidifier to the system.
5. Assemble and connect the patient circuit, connecting tubing and airway pressure tubing to the 3100A HFOV.
6. Turn on the power.
7. Check that the source gas lights are off.
8. Check that the Start/Stop light is off.
9. Check that the alarm silence light is on.
10. Perform the patient-circuit calibration described in the following section.
11. Perform ventilator performance check.
12. Perform the alarm-check procedure as described in the Operators Manual.
13. Preset the flow, frequency, % inspiratory time, power, running mean airway pressure and running mean airway pressure limit.
14. Set the Max Paw and Min Paw thumbwheels.
15. Set the blender and humidifier controls for the desired operation. The use of an external oxygen monitor is suggested.
16. Remove the stopper from the patient circuit and connect it to the patient's endotracheal (ET) tube.

Patient circuit calibration

Perform the patient circuit calibration procedure before ventilating a patient. Each circuit that used on the oscillator must be calibrated. The circuit calibration procedure verifies that the circuit is and will hold pressure. Perform this procedure before placing a patient on the 3100A HFOV.

1. Insert the stopper in the patient circuit wye and turn on the bias flow gas.
2. Rotate the ADJUST and LIMIT control to Max.
3. Set the Max Paw alarm to Max.
4. Set the bias flow to exactly 20 LPM *(the middle of the ball is at the line—you may need to bend down to see this precisely).*
5. Depress and hold RESET *(with the oscillator off).*
6. Observe the mean pressure display and adjust the patient circuit calibration screw *(if needed)* for a reading of 39 to 43 cmH_2O.
    a. Before adjusting the calibration screw, confirm there are no leaks, confirm the bias flow is at 20 LPM and the circuit is set up correctly. See the troubleshooting guide for more information.
    b. Use caution when adjusting the calibration screw. Do not over tighten or apply excessive force because equipment damage may occur.

Ventilator performance check

The ventilator performance check ensures the 3100A HFOV is functioning properly. Perform this procedure before placing a patient on the 3100A HFOV. Insert the stopper in the patient circuit wye and turn on both gas sources.

1. Turn the Adjust control to the 12 o'clock position.
2. Set the bias flow to exactly 20 LPM *(the middle of the ball is at the line—you may need to bend down to see this precisely).*
3. Pressurize the system by pressing and holding Reset and Adjust for a mean pressure of 19 to 21 cmH_2O.
4. Set the frequency to 15.0 Hz, % I; time to 33 and press START/STOP to start the oscillator.
5. Set the power to 6.0 and center the piston.
6. Observe the following parameters using the appropriate altitude range and verify they fall within the ranges specified *(see chart on next page).*

Verify the following parameters according to the altitude of your hospital.

Altitude *(feet)*	mPaw *(cmH_2O)*	ΔP *(cmH_2O)*
0–2,000	15–23	56–75
2,000–4,000	15–23	52–70
4,000–6,000	15–23	48–65
6,000–8,000	15–23	44–60
8,000–10,000	15–23	41–56

Note: See Troubleshooting on pages 19 to 27 for additional information.

Clinical guidelines

Appropriate initial settings using the 3100A HFOV are dependent primarily on the pathophysiology of the lung disease being treated and the patient's birth weight of the patient *(for neonatal patients)*. The clinician must keep in mind that these are likely to change over time as the pathophysiology of the lung disease changes. The clinician must also understand what effect the various settings on the ventilator have on the patient's lung.

Mean Airway Pressure (mPaw)

- Used to keep the lung at optimal lung volume, its main effect will be on oxygenation. However, if it is too low leading to low lung volume *(atelectasis)*, or it is too high leading to high lung volume *(over distension)*, $PaCO_2$ will be adversely affected. When appropriate adjustments are made, $PaCO_2$ will improve.

Amplitude *(delta-P, ΔP)*

- Amplitude is used to ventilate the patient. It has little effect on PaO_2 except when mPaw is too low, then increasing amplitude may increase lung volumes, but is less lung-protective.
- In general, if the set amplitude is approaching three times the mPaw value required for adequate ventilation, the clinician should reassess mPaw, lung volume and frequency.
- Although the 3100A HFOV is capable of generating amplitudes as high as 90 cmH_2O at the patient-circuit wye, those pressures are not developed in the trachea because of respiratory system impedance *(of which the ET tube is the dominant element)*. For instance, at 15 Hz and a compliance of 1 mL/cmH_2O, the amplitude loss is: 90% for a 2.5 mm ET tube, 80% for a 3.5 mm ET tube and 60% for a 4.5 mm ET tube.

Frequency

- Increasing frequency decreases tidal volume and thereby increases $PaCO_2$. Faster frequencies increase the risk or air trapping, which will increase $PaCO_2$ and potentially decrease PaO_2. Because decreasing frequency *(amplitude remaining the same)* increases tidal volume, this will also increase peak to trough pressures in the airways and in the distal lung.
- For most therapeutic situations, a frequency range of 10–15 Hz has been found to be effective for both premature and near-term patients.
- In practice, as patient weight increases, starting frequency is decreased. Frequencies between 6–10 Hz are common in children, and lower frequencies are more typically used for larger children.
- Most of the time, the frequency control remains unchanged throughout the therapy.

Bias flow

- Set bias flow based on the patient's size.

Premature	Near-term	Small child	Large child
10–15 lpm	10–20 lpm	15–25 lpm	20–30 lpm

- In general, use the lowest flow that allows you to achieve the desired settings. Larger patients and higher amplitudes will require the use of a higher flow.

% Inspiratory Time

- For most applications, this parameter remains at 33%. In applications where the patient presents with refractory hypercapnea in the face of maximum ventilatory support, increasing the inspiratory time percent may improve ventilation and may improve lung recruitment.
- Use caution when increasing percent inspiratory time in patients needing longer exhalation times as air-trapping may result.
- The effect of increasing percent inspiratory time is most pronounced at lower frequencies, such as those found in larger pediatric patients.

Managing ventilation

Ventilation

1. Primarily manage ventilation by adjusting the oscillatory pressure amplitude *(ΔP)*. Increasing ΔP improves ventilation. At initiation of therapy, adjust ΔP just high enough to produce perceptible chest wall motion from the nipple line to the umbilicus.

2. If maximum ΔP is unable to sufficiently improve ventilation, employ the secondary strategy of reducing the frequency to take advantage of reduced ET tube attenuation at lower frequency, increasing delivered tidal volume.

   Note: If one or two increases in ΔP do not significantly reduce $PaCO_2$, consider revaluating lung volume and mPaw since under/over-inflation will interfere with ventilation.

3. If elevated $PaCO_2$ still persists, resume frequency reduction.

4. If elevated $PaCO_2$ still persists and adequate lung volume is assured, consider increasing the % Inspiratory Time toward 50% *(for larger pediatric patients)* but be cautious of air trapping.

Managing oxygenation

1. Primarily manage oxygenation by maintaining mPaw at the level necessary to obtain satisfactory pulmonary inflation. A chest x-ray that reveals nine posterior ribs above the level of the diaphragm has been used as an indication of satisfactory inflation.
2. If lung compliance subsequently improves, it will be necessary to reduce mPaw to avoid lung over-inflation.
3. The exception to utilizing higher mPaw to normalize alveolar surface area is air leak syndrome, where it is prudent to accept mPaw similar to conventional ventilation *(lower lung volume)* and utilize a higher FiO_2.
4. Place priority on weaning FiO_2 to less than 0.6 before weaning to lower mean airway pressures. Once the FiO_2 is less than 0.6, shift emphasis to weaning mean airway pressure while still maintaining normal lung inflation and PaO_2.

This chart is excerpted from the operator's manual as an aid to executing your ventilation and oxygenation strategies.

Clinical indicator		Therapeutic intervention	Treatment rationale
FiO_2 above 0.60			
High $PaCO_2$ with:	PaO_2 = acceptable PaO_2 = low PaO_2 = high	Increase ΔP Increase mPaw, ΔP, FiO_2 Increase ΔP, decrease FiO_2	Increase ΔP to achieve optimal $PaCO_2$ Adjust mPaw and FiO_2 to improve O_2 delivery Decrease FiO_2 to minimize O_2 exposure
Normal $PaCO_2$ with:	PaO_2 = acceptable PaO_2 = low PaO_2 = high	No action Increase mPaw, ΔP, FiO_2 Decrease FiO_2	No action Adjust mPaw and FiO_2 to improve O_2 delivery Decrease FiO_2 to minimize O_2 exposure
Low $PaCO_2$ with:	PaO_2 = acceptable PaO_2 = low PaO_2 = high	Decrease ΔP Increase mPaw/FiO_2, decrease ΔP Decrease FiO_2, ΔP	Decrease ΔP to achieve optimal $PaCO_2$ Adjust mPaw and FiO_2 to improve O_2 delivery Decrease FiO_2 to minimize O_2 exposure
FiO_2 below 0.60			
High $PaCO_2$ with:	PaO_2 = acceptable PaO_2 = low PaO_2 = high	Increase ΔP Increase FiO_2, increase ΔP Increase ΔP, decrease mPaw	Increase ΔP to achieve optimal $PaCO_2$ Increase FiO_2 to improve PaO_2 Decrease mPaw to reduce PaO_2
Normal $PaCO_2$ with:	PaO_2 = acceptable PaO_2 = low PaO_2 = high	No action Increase FiO_2 Decrease mPaw, FiO_2	No action Increase FiO_2 to improve PaO_2 Decrease mPaw and FiO_2 to reduce PaO_2
Low $PaCO_2$ with:	PaO_2 = acceptable PaO_2 = low PaO_2 = high	Decrease ΔP Increase FiO_2, decrease ΔP Decrease mPaw, decrease ΔP	Decrease ΔP to achieve optimal $PaCO_2$ Decrease ΔP and increase FiO_2 to improve $PaCO_2$ Decrease mPaw

Patient assessment

Patient assessment should be done routinely and typically includes the following:

1. **Chest wiggle factor (CWF):** Visible bilateral vibration noted from the nipple line to the umbilicus. This check ensures movement of air through the airway structure and lung.
   a. Check for the degree of vibration noted and symmetry.
   b. Question changes in CWF, for example:
      - CWF may increase with improvement in compliance.
      - CWF may decrease with worsening compliance or presence of secretions.
      - Unilateral CWF may be due to slipping of the ET tube down main bronchus or presence of pneumothoraces.
2. **Auscultation:** Breath sounds cannot be heard; however, you may denote changes in the intensity of the piston sounds.
3. **Heart and GI sounds:** Stop piston temporarily; lung inflation will be maintained.
4. Vital signs: HR, BP, MAP, urine output, PCWP, PAP and CVP monitoring are not required, but they are useful tools in ensuring adequate perfusion.

5. Oxygen saturation should be maintained per institutional guidelines for specific disease management.
6. Transcutaneous PO_2 and PCO_2, if available, are useful indications of oxygenation and ventilatory status change.
7. Monitor for adequate perfusion status by assessing capillary refill, skin turgor and color, urine output change and persistent metabolic acidosis.
8. Secretions will present problems with ventilation. Usually secretions are noted by a rapid rise in $PaCO_2$, a decrease in oxygen saturation and a visible decrease in chest wiggle.

ABG

- Sixty minutes post initiation of HFOV
- ABG frequency based on clinical status
- Within one hour of any major settings change or as clinically indicated

Chest x-ray (CXR)

- Within one to four hours post-initiation of HFOV or as clinically indicated
- Whenever lung over-inflation or under-inflation is suspected

Documentation of oscillator settings

Verify and record

- Ventilator settings *(Frequency, Bias flow, % Inspiratory Time, Power, Max Paw, Min Paw, FiO_2)*
- Measurements *(mPaw and amplitude)*

Troubleshooting clinical issues

These clinical troubleshooting guidelines are to help orient you to a possible cause for a clinical change. These only address common problems and are by no means all-inclusive.

Problem:

The patient experiences an abrupt deterioration *(with a rapid rise in $PaCO_2$)* while being mechanically ventilated with the 3100A HFOV *(there may or may not be amplitude changes)*. Consider the following:

- Acute airway obstruction *(mucus plug)*
- Bronchospasm
- Pneumothorax
- Mainstem intubation or extubation

Responses under these circumstances:

- Assess airway function/patency *(e.g., ET tube suctioning, auscultation, $tcPCO_2$ assessment, diminished chest wiggle).*
- Recommend bronchoscopy.
- Draw an ABG if the acute decompensation results in profound hypoxemia *($SpO_2 < 80\%$)* or acute hypotension.
- Notify the physician of these developments immediately and recommend a chest x-ray.
- Consider removing the patient from the oscillator and begin hand ventilating.

Problem:

The patient experiences an abrupt deterioration with a drop in oxygen saturation. Consider the following:

- Airway patency *(mucous plugging)*
- Changes in mean arterial pressure
- Disconnection from the 3100A HFOV device with loss of lung volume
- Possible pneumothorax

Responses under these circumstances:

- Consider fluid boluses and/or pharmacologic support to maintain an adequate mean arterial pressure.
- Re-check the x-ray to assess or rule out presence of pneumothoraces.

Problem: Hypotension

Increased intrathoracic pressure from the elevated mPaw may cause decreased blood flow, resulting in reduced right ventricular preload. Consider the following:

- Fluid bolus
- Pharmacologic support
- Reduce mPaw

Problem:

Elevated CO_2 refractory to increases in Amplitude. Consider the following:

- Mean airway pressure/lung volume is too low. As a general rule of thumb, when the set amplitude is approaching three times the set mPaw, the most common reason is that lung volumes are low, resulting in poor gas exchange.

Responses under these circumstances:

- Increase mPaw
- Re-check the x-ray to assess lung volume

Troubleshooting equipment issues

Circuit does not pass patient circuit calibration

- Visually check for leaks, cracks and open ports on the circuit
- Check cap/diaphragms
- Check the water trap stopcock *(may be open or missing)*
- Ensure the circuit set-up is correct
- Confirm the bias flow is set exactly at 20 LPM *(the **middle** of the ball is at the 20 LPM line—you may need to bend down to see this accurately)*
- Check the airway pressure luer fittings for cracks
- Check the calibration screw *(clicking indicates a defective valve)*
- Confirm the pressure transducer is zero: With the circuit stopper in place, but the system not pressurized, the Paw should read 0 cmH_2O *(± 0.5 cmH_2O)*

Ventilator does not pass the performance check

- Low amplitude:
  - Bypass the humidifier
  - Check the power knob *(0.0 to 10.0)*
  - Check if the humidifier chamber is empty *(may drop the amplitude by as much as 10 cmH_2O)*
  - Bypass the humidifier
- Low mPaw *(with or without low amplitude)*:
  - Crimp the airway pressure line *(mPaw should read 130 to 140 cmH_2O)*
  - Check the flow meter
- Driver does not start oscillating:
  - Check the power knob setting *(must be greater than 0)*
  - Check mPaw *(ensure there are no leaks, and the system is pressurized)*
  - Call CareFusion technical and clinical support

Fluctuating mean airway pressure

- Check for spontaneous breathing
- Cap diaphragm leak: Replace the cap diaphragm
- Check for excessive condensation in the circuit

Low Source Gas LED is illuminated

- This condition indicates an input pressure of less than 30 *(2.0 bar)* psi from either the blender or the cooling air:
  - Check the input gas lines
  - Ensure all hoses are plugged into a gas source
- Check the blender set-up configuration
- Some wye or tee fittings used to split the high-pressure line have an internal restriction: Remove the fitting and reevaluate
- The input water trap filter needs to be replaced: Replace the filter
- Internal leak: Call CareFusion technical and clinical support

High Pressure alarms *(alarm setting or > 50 cmH_2O)*

- Spontaneously breathing: Consider the clinical status of the patient, assess the sedation level or insufficient bias flow rate; re-adjust mPaw using a higher flow
- Obstruction in the expiratory limb or in the pressure sense line: Replace the patient circuit
- Improper setting of the alarm: Change the alarm setting
- Patient circuit temperature rise: Check and correct the circuit temperature
- Interference from a radio transmitter: Remove the source of interference

Low Pressure alarms *(alarm setting or < 20% of the set max mPaw)*

- Spontaneously breathing: Consider the clinical status of the patient, assess sedation level or check for insufficient bias flow rate and re-adjust mPaw using higher flow
- Improper setting of the alarm *(both high and low pressure alarms)*: Change the setting
- Improper setting of the mPaw or flow meter: Change the setting
- Patient circuit temperature drop: Check and correct the circuit temperature
- Leak in the humidifier or patient circuit: Fix the leak or replace the patient circuit
- Cap diaphragm leak: Replace the cap diaphragm
- The water trap stopcock is open: Close the water trap stopcock
- Interference from a radio transmitter: Remove the source of interference

Oscillator stopped with no other alarm occurring

- The power setting is too low and the amplitude is ≤ 7 cmH_2O: Adjust setting for desired amplitude
- Oscillator failure: Call CareFusion technical and clinical support

Amplitude changed during the past few hours while the power setting remained unchanged

- Amplitude increased: Airway resistance increased and/or total lung compliance or volume decreased
- Amplitude decreased: Airway resistance decreased and/or total lung compliance or volume increased
- Changes in amplitude are normal as the patient's pulmonary status changes; assess patient changes in status and adjust ventilator settings if deemed appropriate

General guidelines

- Ventilator circuits should never be reused—washing and sterilizing will reduce their overall performance and increase the risk of malfunction
- Use caution when storing ventilator circuits—some components of the circuits may break if compressed tightly
- Condensation exiting the exhalation valve is normal—the use of personal protective equipment or the filtered oscillator circuit is encouraged
- When not in use, place the driver cover over the front of the driver to minimize risk of damage

Useful information

Clinical and technical support for 3100A/3100B HFOV

Registered respiratory therapists are available for clinical and technical support during normal business hours and for emergency support 24 hours a day.

Call **800.520.4368** and follow the prompts.

3100A/3100B HFOV Rental Program *(United States only)*

The HFOV Rental Program is designed to assist customers who own the 3100A and 3100B HFOV. Delivery will be within 24 hours *(less in most cases).*

This program is available 24 hours a day. Call **800.520.4368** and follow the prompts.

HFOV website

http://www.carefusion.com/hfov

Abbreviations

mPaw	Mean airway pressure
HR	Heart rate
BP	Blood pressure
MAP	Mean arterial pressure
PCWP	Pulmonary capillary blood pressure
CVP	Central venous pressure
ΔP	Delta-P or amplitude

References

1 Gerstmann D, Fouke J, Winter D, et al. Proximal, tracheal and alveolar pressures during high frequency oscillatory ventilation in a normal rabbit model. *Pediatr Res*. 1990; 28(4):367–373. 2 3100A Neonatal disease specific guidelines *(RC3205 Rev. A)*. 3 3100A Operator's manual *(p/n 767124-101 Rev. P).*

Notes

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⚠ **WARNING**—U.S. Federal Law restricts this device to sale by or on the order of a physician.

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 RC2170 (0414/5000) L3458 Rev. C

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