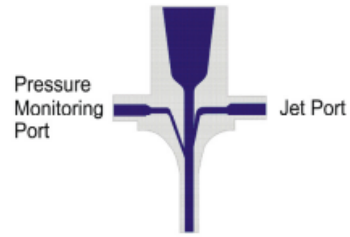
WHAT is the LifePulse High Frequency Ventilator?

The LifePulse is pressure-limited and time-cycled with adjustable rate, PIP, and i-time (T_I). Exhalation is passive.

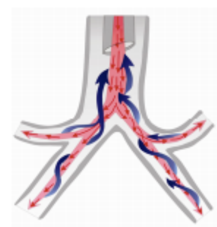
The LifePulse delivers small tidal volumes (V_T) at rapid rates via a special ET tube adapter with built-in jet nozzle. Connecting this “LifePort” adapter to a patient’s endotracheal tube enables tandem use of CMV.

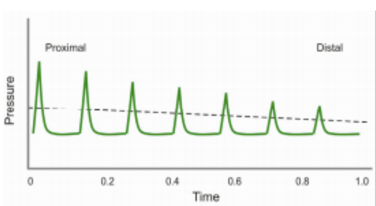


Gas flow is feedback-controlled by matching monitored PIP with set PIP. Monitored servo-controlled driving pressure (“Servo”) is used to detect changes in lung compliance and resistance and acute clinical changes such as accidental extubation, bronchospasm, etc.

Ventilation Controls:

LifePulse high velocity inspirations penetrate through the dead space instead of pushing the resident deadspace gas ahead of fresh gas as we do when we breathe normally. This phenomenon enables approximate $V_T \approx 1$ mL/kg body mass, about half the size of anatomic dead space volume. Pressure amplitude (PIP-PEEP) produces V_T and controls $PaCO_2$. Exhaled gas cycles out in a counter-current helical flow pattern around the gas jetting in as shown here, which facilitates mucociliary clearance in the airways.





HFJV PIP may be as high or higher than that used during CMV. However, because inspirations are so fast and brief, PIP falls quickly as HFJV breaths penetrate down the airways, and peak alveolar pressure is much lower than peak airway pressure as shown below.

The LifePulse uses passive exhalation. Thus, airway pressure at end-exhalation, PEEP, is constant throughout the lungs, as long as rate is set appropriately to avoid gas trapping.

Rate is usually set 10 times faster than CMV rates, in proportion to patient size and lung time constants (lung compliance x airway resistance). Lower rates enable longer exhalation times (T_E), which aids in the treatment of larger patients and infants with restricted or obstructed airways. At 420 bpm (7 Hz), I:E = 1:6.1 where at 240 bpm (4 Hz), I:E = 1:12.

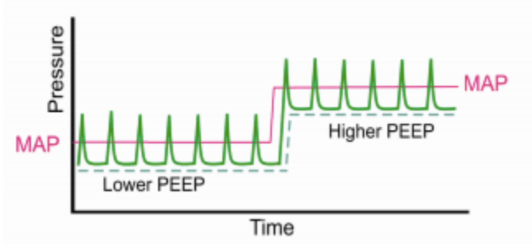
Since rate does affect minute ventilation, lowering rate may require raising PIP to maintain $PaCO_2$, because LifePulse V_T is independent of rate. But, LifePulse V_Ts are still much smaller than CMV V_Ts because of their very short T_Is.

T_I is usually started at the minimum default of 0.020 sec, because it minimizes ventilation of the injured areas of the lungs. Longer T_I can be used on patients with longer inspiratory time constants to increase delivered tidal volume and lower $PaCO_2$.

Oxygenation Controls:

PEEP is the primary determinant of mean airway pressure (MAP) and lung volume. The PEEP on HFJV is set by using the conventional ventilator operating in tandem with HFJV. Oxygenation on HFJV is directly proportional to MAP which is similar to CMV and HFOV; however, with HFJV, the MAP should be generated primarily by PEEP. A small contribution comes from the LifePulse settings. Recruitment maneuvers can be utilized as needed by setting a CMV rate of 2-5 bpm to facilitate alveolar recruitment with its larger Vts.

This approach produces an HFJV version of "lung protective ventilation," where alveoli are opened with temporary CMV recruitment breaths, kept open with appropriate PEEP, and ventilated as gently as possible. Gas for patient's spontaneous breathing is provided by the CMV.



PEEP is the primary control for MAP and oxygenation

Gas Trapping Considerations:

Gas trapping occurs when V_T s have insufficient time to exit the lungs. CMV tidal volumes present a greater threat of gas trapping compared to much smaller HFJV breaths. CMV rate should therefore be reduced before HFJV rate whenever there are indications of gas trapping, such as hyperinflation on chest x-ray or when LifePulse monitored PEEP exceeds CMV set PEEP. If hyperinflation persists once the CMV is in CPAP mode, LifePulse rate is decreased in 60 bpm increments to lengthen I:E ratio and T_E.

Applications:

PIE is the most common indication for the LifePulse, because it improves ventilation/perfusion matching and facilitates healing by reducing mechanical ventilation of the most injured and poorly functioning areas of the lungs. Ability to extend exhalation time by decreasing rates helps to prevent and treat hyperinflation.

PIE is characterized by inflamed airways with high airway resistance that creates gas trapping, pulmonary overdistension, and alveolar disruption when other forms of mechanical ventilation are used. Since high airway resistance deters high velocity inspirations, resolution of PIE is much more likely using the LifePulse.

Other airleaks, meconium aspiration and other pneumonias (especially those accompanied by excessive secretions), congenital diaphragmatic hernia, and PPHN are other common applications of the LifePulse as reported by NICU users, while trauma and severe pneumonia are reported applications in PICUs. Some institutions also use the LifePulse during and after pediatric surgery (e.g., Fontan procedure, CDH and TEF repair), especially when complicated by respiratory failure.

Randomized controlled trials support use of the LifePulse for uncomplicated RDS, RDS complicated by PIE, and PPHN. There is an abundance of anecdotal experience to support use of the LifePulse for treating chronic lung disease in preterm and term infants, and emerging literature supports using the LifePulse as an early intervention tool to prevent PIE and CLD.

Complications:

Hyperventilation with any ventilator can increase incidence of cystic periventricular leukomalacia in premature infants. Appropriate monitoring of ABG status should be utilized. Transcutaneous CO_2 monitoring is strongly recommended to reduce this risk.

Servo:

Servo auto-regulates gas *flow* to the patient to keep monitored PIP = set PIP. It can be used as a tool to trend changes in the patients condition.

Servo Pressure Increases with:

- Improving lung compliance or airway resistance, which can lead to hyperventilation when ignored
- Leaks in ventilator circuit leading up to the patient
- Excess moisture in the LifePort adapter causing pressure monitoring interference

Servo Pressure Decreases with:

- Worsening lung compliance or airway resistance, which can lead to hypoxemia when ignored
- Obstructed ET tube (e.g., from a mucus plug)
- Accumulating secretions at the end of the ET tube (e.g., patient needs suctioning)
- Tension pneumothorax
- Right mainstem intubation

Monitoring Servo Pressure helps you determine if the patient is getting better or worse after you administer surfactant, make a change in ventilator management strategy, or reposition the patient.

For more information, visit www.bunl.com or call us at 800-800-4358.