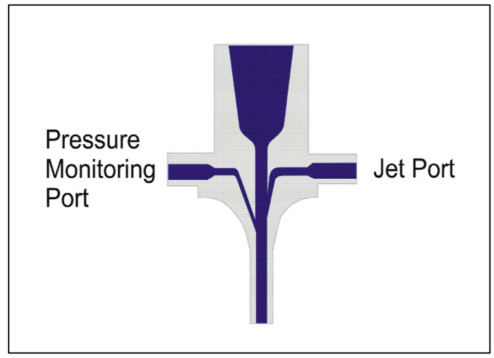
INSPIRED INFANT CARE

WHAT is the LifePulse High Frequency Ventilator

Description:

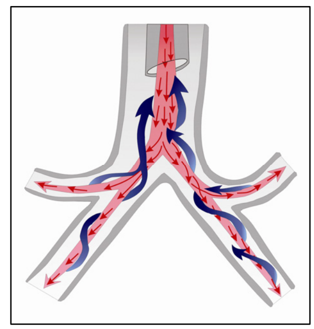


The LifePulse is pressure-limited and time-cycled with adjustable rate, PIP, and On-time (T_I). Exhalation is passive.

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 or tracheotomy tube enables tandem use of CMV.

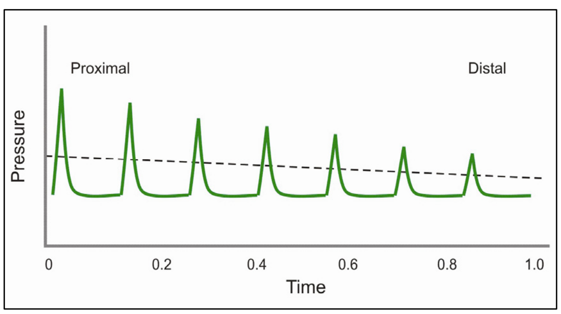
Gas flow is feedback-controlled by matching monitored PIP with set PIP. Monitored servo-controlled driving pressure (Servo Pressure) is used to detect changes in lung compliance and resistance and mishaps such as pneumothorax, accidental extubation, bronchospasm, etc.

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 $V_T \approx 1$ 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.

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 slow enough 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 240 bpm (4 Hz), I:E = 1:12. Smaller patients may be treated at rates up to 660 bpm (11 Hz) where I:E = 1:3.5.

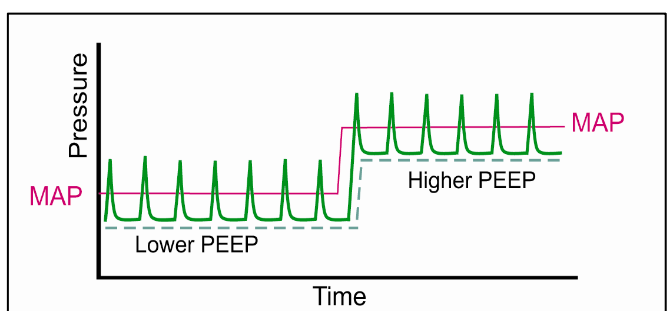
Lowering rate may require raising PIP to maintain $PaCO_2$, because LifePulse V_T is independent of rate. But, LifePulse V_Ts are still much smaller than CMV V_Ts because of their very short T_Is.

T_I is usually kept at its minimum: 0.020 sec., because it minimizes ventilation of injured areas of lungs. Longer T_Is are only used when more time is needed to deliver V_Ts in lungs that have diffuse and chronic injury.

Oxygenation Controls:

CMV settings control oxygenation. CMV at 2-5 bpm facilitates alveolar recruitment with its larger V_Ts. PEEP is the primary determinant of mean airway pressure (MAP) and lung volume.

Optimal PEEP may be found using CMV breaths and pulse oximetry. CMV MAP prior to starting HFJV is reproduced at start-up by raising PEEP 1-2 cm H_2O initially. Patients are then stabilized with CMV = 5 bpm and F_IO_2 adjusted to produce appropriate SaO_2. CMV is then switched to CPAP mode, and PEEP is increased until SaO_2 restabilizes. Thus, CMV breaths are typically used intermittently.



PEEP is the primary control for MAP and oxygenation

This approach produces an HFJV version of "lung protective ventilation," where alveoli are opened, kept open with appropriate PEEP (usually in the range of 8 - 10 cm H_2O), and ventilated as gently as possible. Gas for patient's spontaneous breathing is provided by the CMV.

Gas Trapping Considerations:

Gas trapping occurs when V_Ts 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 xray 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.

V_Ts necessary to produce adequate ventilation at high rates are very small, and lung compliance is low in preterm infants, so gas trapping is unlikely to occur with the LifePulse. However, the maximum rate of 660 bpm is rarely used, even in preemies weighing less than 1000 grams. Most LifePulse users limit rate to 540 bpm (9 Hz) where I:E = 1:4.5 and $T_E = 0.091$ sec.

Applications:

While some clinicians use the LifePulse for preterm infants with uncomplicated RDS, it is most often used to rescue infants and children with lung injury. PIE is the most common indication for the LifePulse, because it automatically improves ventilation/perfusion matching and facilitates healing by reducing mechanical ventilation of the most injured and poorly functioning areas of the lungs.

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 in NICUs, while trauma and severe pneumonia are typical applications in PICUs. Some institutions also use the LifePulse during and after pediatric cardiac surgery (e.g., Fontan procedure), 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. Strategy for these patients is low LifePulse rate (240 bpm), no CMV breaths, and moderate PEEP (8-10 cm H_2O). [Note: PEEP is needed to keep airways as well as alveoli open. Reducing PEEP to lessen gas trapping may make matters worse by allowing small airways to collapse during exhalation.]

Complications:

Hyperventilation with the LifePulse is associated with increased incidence of cystic periventricular leukomalacia in premature infants with moderate RDS. A single center study revealed such increased adverse effects when the LifePulse was used with low PEEP (5 cm H_2O) where hyperventilation and inadequate oxygenation occurred during the first 24 hours of life. (Inadequate PEEP leads to using higher PIP to generate more MAP for better oxygenation that, in turn, causes hyperventilation.) Transcutaneous CO_2 monitoring is strongly recommended to reduce this risk.

Servo Pressure:

Servo Pressure auto-regulates gas *flow* to the patient to keep monitored PIP = set PIP. The following examples are typical of what automatically set upper and lower Servo Pressure alarms indicate.

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.