

**VANDERBILT UNIVERSITY MEDICAL CENTER
DIVISION OF TRAUMA AND SURGICAL CRITICAL CARE**

TRAUMA/BURN/SICU VENTILATOR MANAGEMENT PROTOCOL

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Policy

All patients requiring mechanical ventilation in the Trauma/Burn/Surgical Intensive Care Units are managed following this protocol unless otherwise ordered by their physician in the computerized physician order entry system (CPOE).

A. All changes to the ventilator strategy will require effective communication to the current team. The team members include the Attending, Fellow, Resident, Nurse Practitioner, Bedside Nurse, and Respiratory Therapist. Inadvertent changes to the ventilator are not made. Any deviation from the protocol will require specific orders entered into the CPOE system.

B. Maintaining continuity of care and communication plan:

Day shift- the Respiratory Therapist reviews all patients' ventilator orders and plan for the day with the critical care team during rounds (if unavailable discuss with the Fellow or NP after morning rounds).
Night shift- the Respiratory Therapist reviews all patients' ventilator orders and plan for the night with the Fellow or NP after evening rounds.

Initial Ventilator Management

A. **MODE:** PRVC (Pressure regulated volume control) with SIMV (Synchronized intermittent mandatory ventilation) is the preferred mode of ventilation. Alternative modes of ventilation may be used when discussed with the team.

B. **Tidal Volume:** 6 mls/kg (IBW) initially and insure the Pplat is <30 cmH₂O. If Pplat is >30, decrease V_t by 1ml/kg to a minimum of 4-5 ml/kg. Notify Attending or Fellow should you have to reduce the tidal volume to decrease Pplat.

Use IBW to determine tidal volume:

FEMALES IBW (kg) = (height in inches – 60) * 2.3 + 45.5

MALES IBW (kg) = (height in inches – 60) * 2.3 + 50

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- C. **Rate:** 12-16 breaths per minute. Titrate rate to maintain a normal range of pH 7.37-7.42. Attempt to maintain PCO₂ <55mmHg, correct by adjusting respiratory rate. Contact Attending or Fellow if unable to maintain pH 7.32-7.42, or if PCO₂ is >55mmHg.
- D. **Pressure Support:** If patient has a spontaneous tidal volume, titrate Pressure Support setting to maintain tidal volume minimum of 4-5 ml/kg, typically 10 cmH₂O.
- E. **FiO₂:** Initiate at 100% and titrate FiO₂ to maintain SpO₂ ≥ 92%. Wean patient to the lowest level of FiO₂ and PEEP while maintaining SpO₂ >93%. Goal is FiO₂ .40 and SpO₂ >92%.
- F. **PEEP:** In an effort to recruit alveoli and increase surface area to improve gas exchange start all patients with 5-10 cm H₂O PEEP. Compliance measurements should be utilized as a reference point for further PEEP adjustments. Weaning PEEP should also utilize this measurement to guide appropriate changes in PEEP in conjunction with FiO₂ changes without compromising compliance. Note: On the Servo I static compliance measurements can be automated, and should be used to decrease variability in clinician calculations. Minimum PEEP setting is 5 cmH₂O.

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Daily Readiness to Wean Assessments:

- A. **Spontaneous Breathing (SCREEN) Readiness Assessment:** to be completed prior to or during morning rounds by the Respiratory Therapist/Nurse (7am/7pm) based on the following criteria:

PASS SCREEN

- Hemodynamics are stable, no significant dysrhythmias, ischemia, or high dose inotropes.
- Minute ventilation less than 10l/min.
- Fluid, electrolyte, and acid/base status are appropriate.
- FiO₂ (inspired oxygen) less than or equal to 0.50 and PEEP ≤ 8 cm H₂O.
- Patient is without neuromuscular blockade.
- Patient is triggering ventilator or will trigger ventilator when set rate is decrease by 50%.
- No open abdomen
- No Traumatic brain Injury GCS ≥ 8.
- Not using the VDR or BIVENT mode of ventilation.

- B. **Initiate SBT (Spontaneous Breathing Trial/CPAP Trial)-30 minute trial**

- Maintain current FiO₂.
- CPAP- 5 cmH₂O and PS (pressure support)- 0

Document on the ventilator flow sheet and in **Mediserve template name "Spontaneous Breathing Trial SBT"**

- C. Evaluate patient during SBT, **successful if:**

- Respiratory rate < 35 BPM
- HR < 140 or within 20% of baseline
- No complaints of respiratory distress
- No anxiety or diaphoresis
- Titrate FiO₂ to maintain SpO₂ ≥ 93%
- Contact MD with results of SBT; obtain order to initiate weaning protocol.

- D. **Weaning and/ or SBT Failure**

If any of the following occur, document SBT failure and place the patient back on previous ventilator settings. Document reason for SBT failure in Mediserve and on Ventilator flow sheet at the bedside. Notify physician or NP of failure.

- BPM greater than 35 (less than or equal to 5 minutes at BPM greater than 35 may be tolerated)
- Minute Volume greater than 10 l/m.
- SpO₂ less than 90% saturation
- Systolic Blood Pressure greater than 180 or less than 90 mmHg
- Respiratory Distress
 1. HR greater than 120% of baseline HR (Less than 5 min of increased HR may be tolerated)
 2. Marked use of accessory muscles
 3. Abdominal paradox
 4. Diaphoresis
 5. Marked subjective dyspnea
 6. Apnea

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- E. **Weaning:** With a physician's order in the CPOE system for "Surgical PCC Protocol Wean" initiate the following weaning protocol.

The weaning process will be broken down in two sections Oxygenation and Ventilation:

VENTILATION: Goal- Pressure Support 5 cmH₂O, respiratory rate < 35, Minute Ventilation > 5lpm.

- Change current mode of ventilation to Pressure Support and titrate pressure support to deliver tidal volume 4-5 mls/kg or 300 mls.
- Continue to drop PS (pressure support) level by increments of 5 cmH₂O as long as patient maintains adequate minute volume (70% baseline on previous mode) and a respiratory rate <35 bpm.
- If patient's respiratory rate > 35 bpm, increase PS level to previous setting. If patient's respiratory rate remains >35 bpm change back to PRVC or previous mode, notify physician or NP and document all information on the ventilator flowsheet including name of practitioner notified.

OXYGENATION: Goal- FiO₂ ≤ 40%, PEEP 5 cmH₂O, SpO₂ ≥ 93%

- If FiO₂ > 50% wean in increments of 10% to an FiO₂ of 40% while maintaining SpO₂ ≥93%
- Wean PEEP to 5 cm H₂O decrease in increments of 5 cmH₂O every 30 minutes or as tolerated by maintaining SPO₂ ≥ 93%.
- If SpO₂ drops below 93% increase PEEP to previous level to bring SPO₂ back up. Anytime the SPO₂ does not respond to 2 consecutive increases in FIO₂ or PEEP notify physician or NP and document all information on the ventilator flowsheet including name of practitioner notified.

F. **Post Extubation Protocol**

- **Initiate oxygen therapy with a nasal cannula, titrate liter flow to maintain oxygen saturation ≥93%.**
- Start Incentive Spirometry (IS) q 1 hour X 4 hours
- After 8 hours change IS frequency to Q2-4h WA until ambulatory.
- If at any time IS <8 ml/kg IBW, begin Acapella Therapy q 4 hours, notify physician or NP and document all information in Mediserve including name of practitioner notified.
- For patients with expiratory wheezing begin bronchodilator- Albuterol Q4H via hand held nebulizer unless patient is effectively able to use an MDI. For ventilator patients use an MDI and spacer to administer.

Heated Humidity vs. Heat Moisture Exchanger

Criteria to use Heated Humidity for inspired gases:

- Body temp < 32
- Bloody secretions
- Facial Trauma
- ≤ 7.0 mm ETT
- MV > 12-15 LPM
- Thick tenacious secretions

Criteria for HME:

- When none of the above conditions exist.

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Procedure: BiVent Clinical Practice Guidelines with the Servo i

DESCRIPTION

A Pressure Control mode with mandatory breaths utilizing 2 pressure levels, a modified form of CPAP, in which the patient is able to breath spontaneously unrestricted at both levels and if desired with the addition of Pressure Support. The Servo *i* allows this due to the floating/active exhalation valve.

GOAL

To provide the recognized strategy of lung protective ventilation supported by the ARDSnet research by delivering small distending volumes and reestablishing FRC through recruitment and maintained by creating intrinsic PEEP (PEEPi). The management of BiVent should be approached from this perspective.

BENEFITS

- Patients are able to breathe spontaneously throughout the ventilatory cycle. Since the activity of the diaphragm and intercostal muscles is not inhibited, there is a resultant improvement in matching of ventilation and lung perfusion. .
- Reduction in intrapulmonary shunting and dead space ventilation is associated with spontaneous breathing.
- Venous return and cardiac performance may be improved
- Preserved diaphragmatic activity may recruit consolidated lung areas over time and thus improve oxygenation.
- Neuromuscular blockade may be eliminated, improvement in cardiac and renal function may be realized, lower ventilation pressures will protect the lungs while increasing oxygenation, and sedation may be reduced.
- BiVent may be a more comfortable mode of ventilation for the acutely ill patient.

TERMINONOLOGY

1. P High is the upper PEEP (CPAP) level. P High is analogous to MAP and thus affects oxygenation.
 - a. This establishes the upper pressure level and should be at or close to the patient's FRC. Patients can breath spontaneously at this level at any time.
 - b. Overdistension will occur when a P High set too high.
 - i. Assess the patient's spontaneous respiratory effort. If, during the release phase (T PEEP) they are actively exhaling, the patient is struggling to get back down to FRC.
 1. Decrease P High so FRC can reestablish
 2. Increase T PEEP so FRC can reestablish

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BiVent Clinical Practice Guidelines with the Servo i

- c. At P High the patient may show abdominal and accessory muscle excursion with expiratory flow appearing in the graphics. At the same time, inspiratory efforts should be minimal, adjust Trigger. As recruitment takes place, the spontaneous tidal volumes will increase.
2. T High is the inspiratory time IT(s) phase for the ventilator control breaths.
 - a. This is your set rate control
 - b. The shorter the T High the more releases/minute.
 - i. It's during the release phase that PCO₂ is eliminated.
3. T PEEP (T Low) is the expiratory time ET(s) phase for the ventilator control breaths.
 - a. Changes in T PEEP will affect PEEP_i.
 - i. When T PEEP is increased it will decrease PEEP_i
 - ii. When T PEEP is decreased it will increase PEEP_i.
 1. PEEP_i should be measured. PEEP_i should be monitored to ensure there is no derecruitment or overdistention.
4. T High + T PEEP is the total cycle time for control breaths
 - a. Determines the I:E ratio
 - i. The clinician should note that through manipulation of the T High/T PEEP combination, extreme ranges in total MVE and I:E ratio are possible.
5. P Low is the level of mechanical PEEP (CPAP) at baseline.
 - a. Normally is set to zero. Due to the inverse ratios a high level of PEEP_i will be achieved.
 - i. The exceptions will be those patients whose compliance is decreased causing their respiratory time constants to be very short. In those cases, a set PEEP may prevent the faster lung units from completely collapsing. It will be necessary to balance such protection against CO₂ evacuation. MAP is minimally influenced but ventilation may be hindered as P Low is increased.
6. Pressure Support (P High/T PEEP)
 - a. PS may be added to augment the patient's tidal volume at P High and/or T PEEP.
 - i. Caution must be used when adding Pressure Support above the set P High, as patients may be at or near their inspiratory capacity and extra pressure may cause overdistention.

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IMPORTANT POINTS

1. 75-25% PEF (peak expiratory flow) goal - The 75-25% PEF goal is primarily for oxygenation
 - a. The T PEEP should be titrated so the expiratory flow terminates inside the 75-25% PEF zone.
 - b. Allowing an expiratory flow to get closer to the 25% PEF end of the range, which may offer better CO₂ evacuation, can augment elevated PaCO₂.

It is important, however, that the lung not be derecruited. It is important the PEEP_i be assessed during this decision process. Changes in the T PEEP will alter this value.

PROCEDURE

Prior to initiating BiVent, the RCP will...

1. Calculate the P/F ratio from the most recent ABG
2. Using the results of #1, choose the MAP from the following table:
(Steps 2, 3, 4, 5, & 6 are starting points only, adjust as necessary according to patient response, ABGs and other physiological parameters)

<u>If P/F is:</u>	<u>use MAP of:</u>
<300	10-15
<250	15-20
<200	20-25
<150	25-30

3. Set the P High at 3 cm above the MAP selected in step #2 but, **do not exceed a MAP of 30 cmH₂O without the physician's approval.**
4. Set the PEEP (P Low) at zero
5. Set the T PEEP at 0.5s
6. Using the following table select a T High that results in a total frequency approximating the rate set on conventional ventilation.

<u>T High (s)</u>	<u>T PEEP (s)</u>	<u>Frequency</u>
3.0	0.5	17
4.0	0.5	13
5.0	0.5	11
6.0	0.5	9

7. Initiate BiVent
8. Review the total minute ventilation, oxygen saturations, and the expiratory flow curve.

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MANAGEMENT OF PaO₂

1. To increase PaO₂
 - a. Increase MAP by increasing P High. in 2 cmH₂O increments.
 - b. Shorten T PEEP to increase PEEP_i in 0.1 cmH₂O increments

MANAGEMENT OF PaCO₂

1. To decrease PaCO₂

- a. Decrease T High.
 - i. This increases MVE by creating more airway releases/minute.

2. To increase PaCO₂

- b. Increase T High
 - i. This decreases MVE by creating less airway releases/minute.

(In general, it is better to accept hypercapnia than sacrifice the MAP from which the oxygenation arises.)

WEANING

The overall weaning strategy shall be to reduce the most invasive parameter first. It is recommended that the physician establish these priorities.

1. As usual FiO₂ should be weaned first.
2. Reducing P High, by 2cmH₂O increments until the P High is below 20 cmH₂O.
3. Increasing T High by 5 releases/minute increments (which reduces the ventilator set rate) until the patient is essentially on CPAP with very few releases.
4. Patients should be increasing their spontaneous rate to compensate.
5. Add Pressure Support judiciously. When adding Pressure Support decrease P High, to avoid overdistention, yet try to maintain a consistent MAP.

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5. Sydow M. Burchardi H. Ephraim E. Zielmann S. Crozier TA. “Long-term effects of two different ventilatory modes on oxygenation in acute lung injury. Comparison of airway pressure release ventilation and volume-controlled inverse ratio ventilation.”

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Volumetric Diffusive Ventilation using the VDR Ventilator

BASIC VDR®-4 ADULT SET UP INSTRUCTIONS

CLINICAL STRATEGIES

Programming of the VDR®-4, to correct arterial blood gas abnormalities is an art, based upon a few simple principles and the rationalization of pressure limited ventilation, as well as understanding the advantages and disadvantages of traditional high frequency ventilation.

INITIAL PATIENT SET UP (ADULT)

INITIATING VDR® PROGRAMMING

FIO2 saturation's	As needed to maintain arterial >90%
INSPIRATORY TIME	2 seconds
EXPIRATORY TIME	2 seconds
RESPIRATORY RATE	15 bpm
PULSE FREQUENCY	500 bpm
PULSE i/e RATIO	1:2
PULSATILE FLOW	20-30 cm H2O and/or 2/3 PIP of ventilator setting if in the volume control mode, Match PIP of ventilator setting if in the pressure control mode. (Once these setting have been established the Pulsatile Flowrate is adjusted by patient assessment, ABG's, etc.)
OSCILLATORY CPAP	8 cm H2O for spontaneously breathing patients 10 cm H2O for patients not breathing.
DEMAND CPAP	2 cm H2O for spontaneously breathing patients 0 cm H2O (OFF) for patients not breathing
NEBULIZER	Full counterclockwise for maximum output
FAILSAFE SENSING	Full clockwise for adult
CONV PRES RISE	As needed

Reference : www.Percussionaire.com

The following is an excerpt from the website of Percussionaire, please see the entire website for all details. www.Percussionaire.com

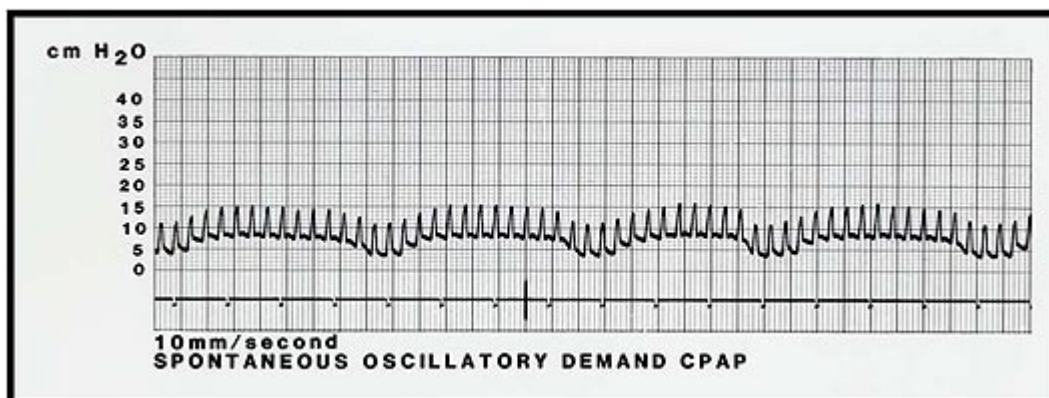
Percussionaire® Corporation Educational Documents

A COMPENDIA OF THE MECHANICAL VENTILATION OF THE LUNG AS IMPACTED UPON, BY THE LIFE LONG CONTRIBUTIONS OF FORREST M. BIRD, M.D., PhD., ScD.

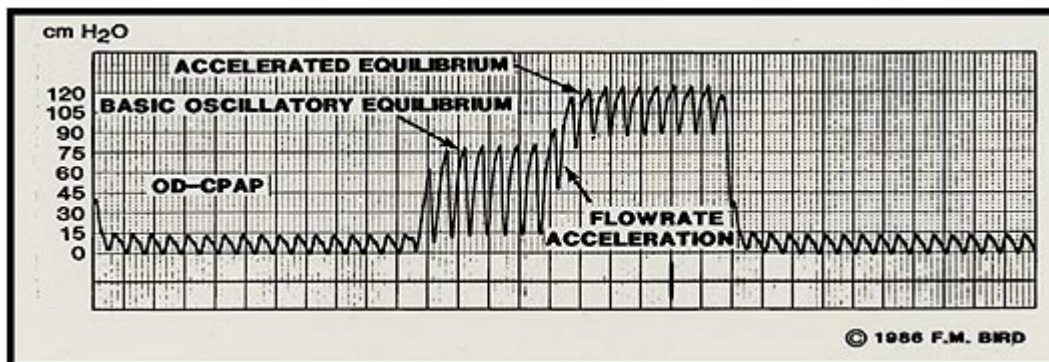
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AN OVERVIEW OF VOLUMETRIC DIFFUSIVE RESPIRATION (VDR®)-

THE PERCUSSIONAIRE® VDR®-4 HIGH FREQUENCY PERCUSSIVE VENTILATION (HFPV™) IS THE PROFESSIONAL VENTILATOR FOR “THE PROFESSIONAL CLINICIAN”



HIGH FREQUENCY OSCILLATORY DEMAND CPAP SUPPORTING SPONTANEOUS RESPIRATION



TYPICAL MULTIPLE STAGE VDR®PERCUSSIVE LUNG INFLATION

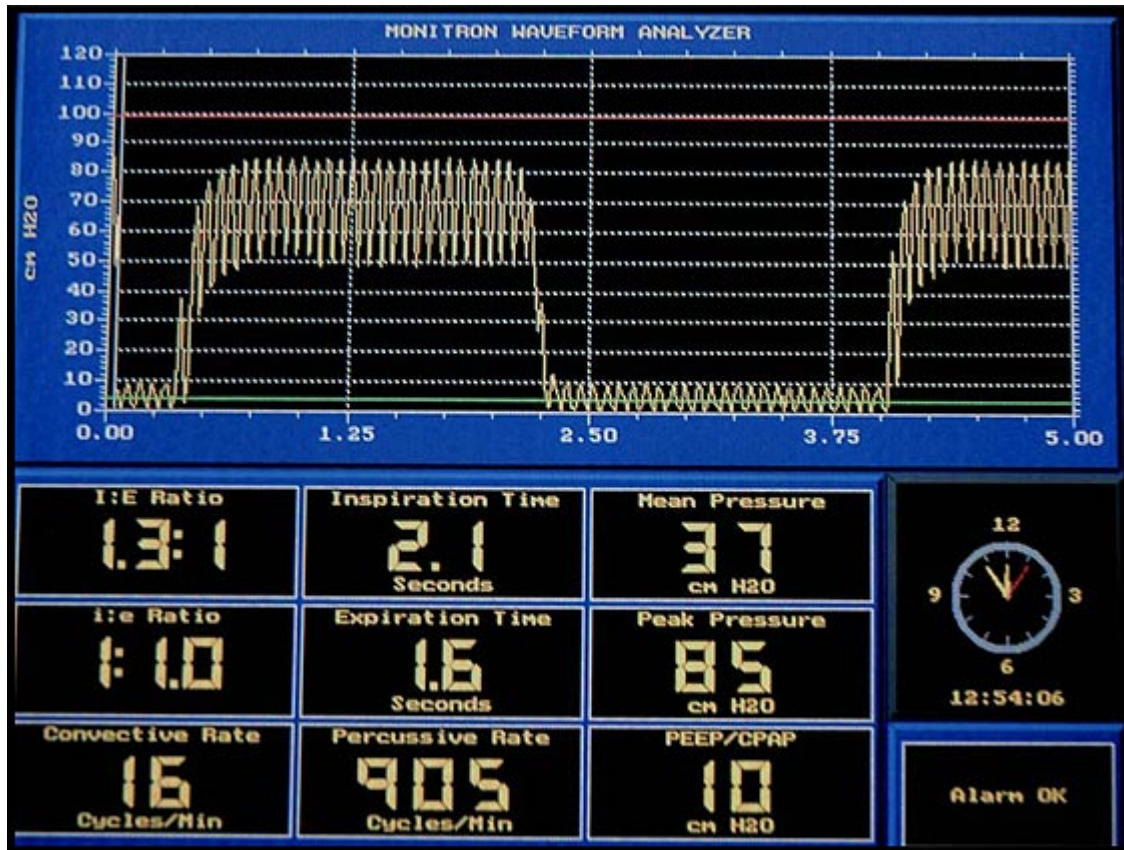
**THE UNIQUE VDR®-4 CRITICAL CARE VENTILATOR provides DIFFUSIVE/CONVECTIVE
CARDIOPULMONARY SUPPORT**

to the most critical Neonates through Pediatrics to the largest Adult



The independent fluidic VDR®-4 critical care ventilator (Percussionator®) is monitored by a high frequency wave form analyzer (Monitron®), which provides, about a three millisecond response presentation of a pictorial wave format and a digital read out of key VDR®-4 ventilatory programming.

Volumetric Diffusive Ventilation using the VDR Ventilator

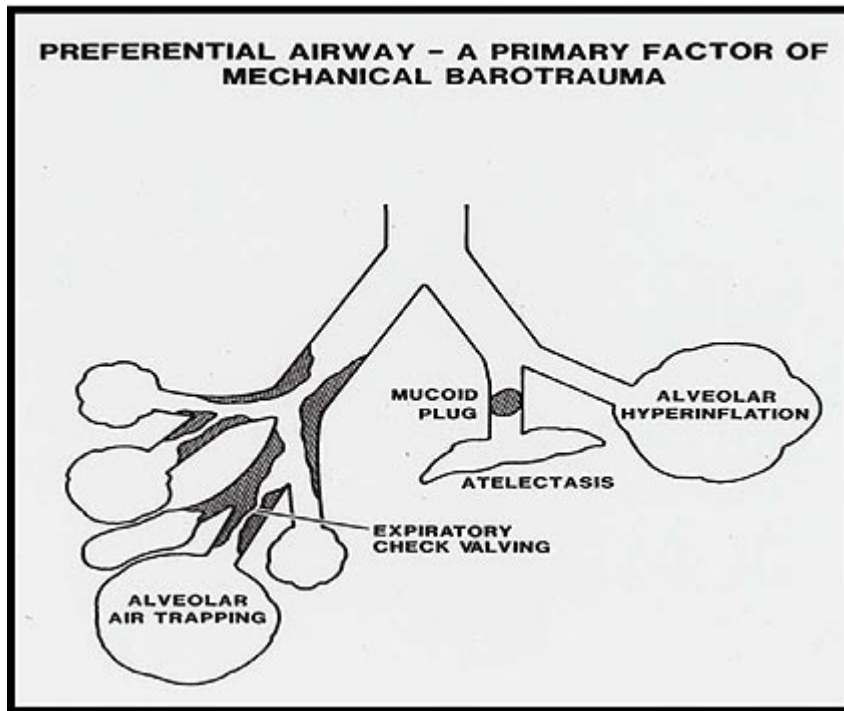


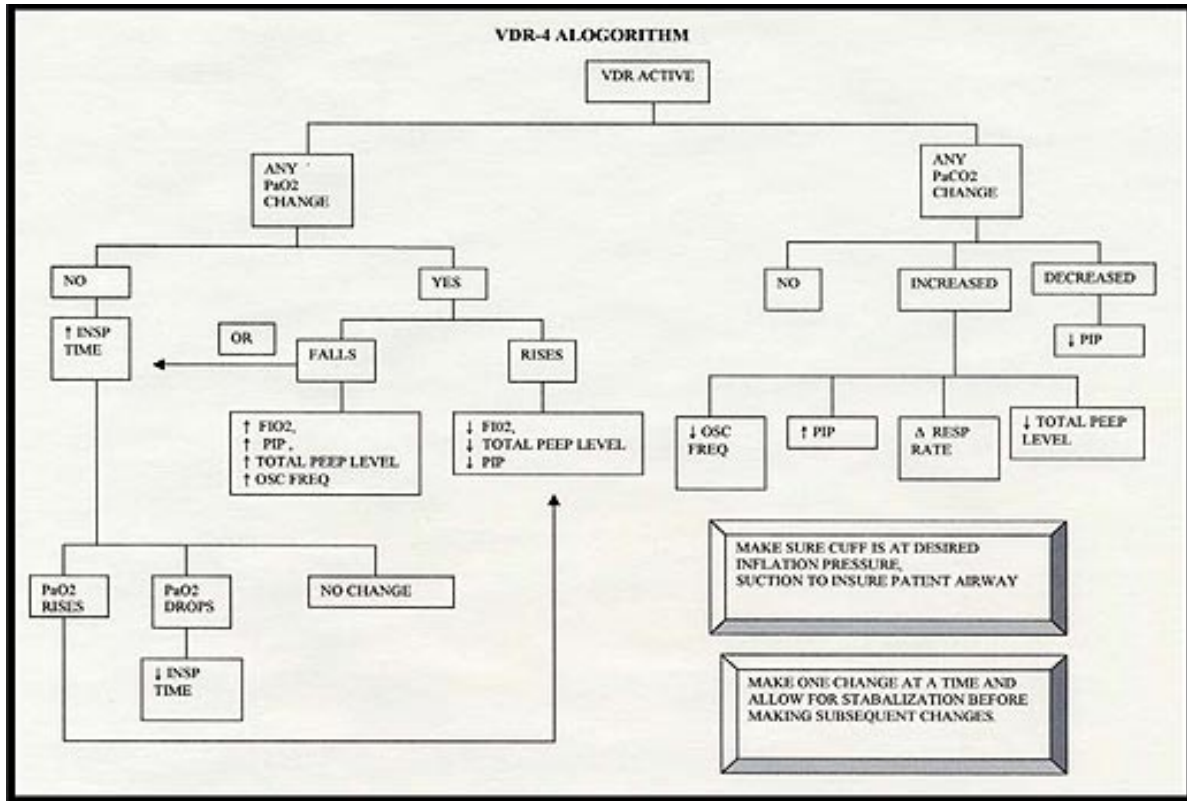
Monitron Wave Format with digital readout of both Diffusive and Convective Ventilation

Volumetric Diffusive Ventilation using the VDR Ventilator

Volumetric Diffusive Ventilation using the VDR Ventilator

PREFERENTIAL AIRWAY - A PRIMARY FACTOR OF MECHANICAL BAROTRAUMA





The above algorithm was created by clinicians with substantial VDR® experience, for general educational purposes.

The combination of difussive intrapulmonary gas mixing with a convective intrapulmonary gas exchange can manage the most critical patient with obstructive endobronchial airways resultant from mucosal and sub mucosal edema and retained endobronchial secretions.