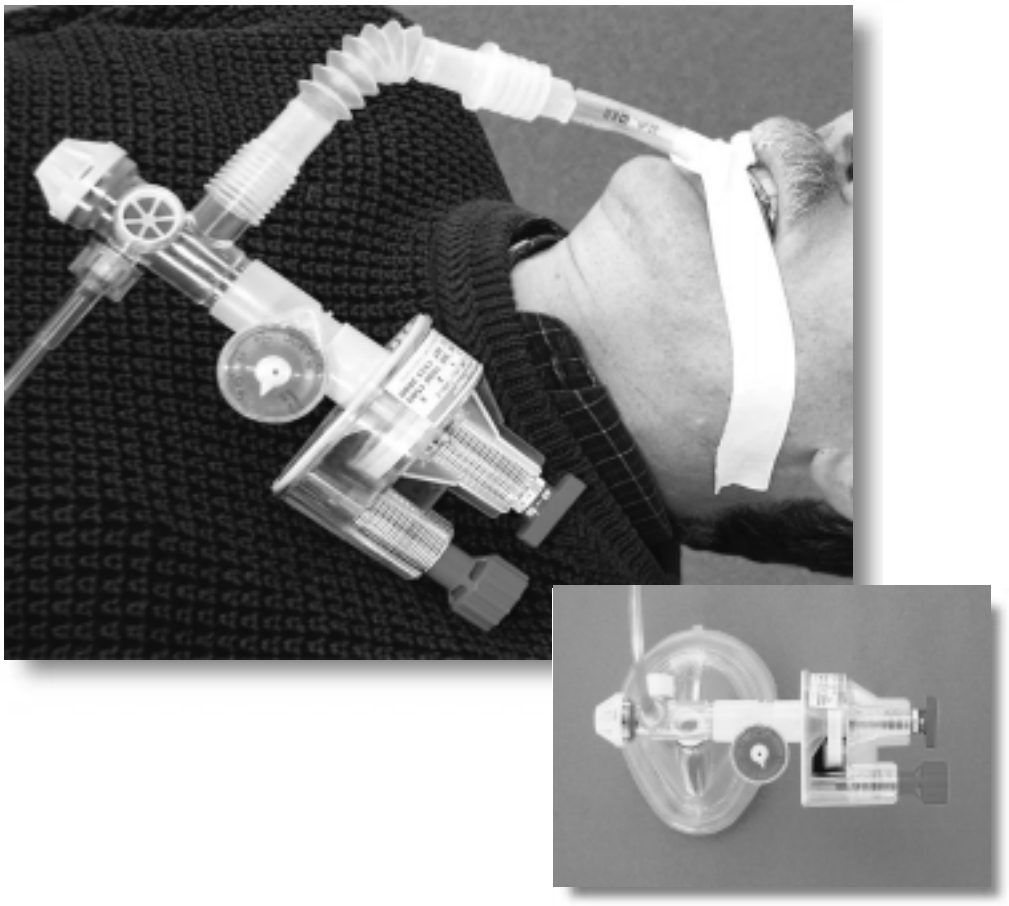
SUREVENT™

Advances in Prehospital Ventilation



An EMS Training Guide for the SUREVENT™ Emergency Transport Ventilator

HARTWELL MEDICAL

6352 Corte del Abeto, Suite J
Carlsbad, CA 92009-1408

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ADVANCES IN PREHOSPITAL VENTILATION

Written by: Barry Hickerson, EMT-P, FP-C

Objective: To familiarize prehospital care personnel with advances in ventilatory support which will enable them to identify and understand the limitations of current methods and devices. This material serves as an introduction for use of the SUREVENT™ only and should be used in conjunction with a formal, organized training effort prior to use of the SUREVENT. Always consult your local EMS Agency, EMS Provider and your Medical Director prior to using this or any new medical device.

EMS TRAINING GUIDE

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VORTRAN Medical Technology 1, Inc. of Sacramento, CA. and Hartwell Medical of Carlsbad, CA

I. THE BASICS

In this section you will learn:

- Oxygenation and ventilation
- Tidal volume
- Minute volume
- I:E ratios
- Typical ventilation pressures
- Common terms

Treatment of respiratory disorders in the emergency setting typically involves increasing the oxygen concentration of inspired gases or supplementing the respiratory effort. Any patient that has insufficient oxygenation or respiratory effort needs immediate intervention. This intervention may be in the form of providing more oxygen by using an oxygen cannula, mask or other delivery device. The necessary intervention may also include an increase in tidal volume, respiratory rate, or complete ventilatory support in the case of a respiratory or cardiac arrest.

Don't confuse the need to provide supplemental oxygen to a patient that is in need of ventilatory support. A patient that has a low respiratory rate or decreased tidal volume needs ventilatory support which should be supplied by a BVM or other resuscitator. Patients with low oxygen levels need oxygen therapy with an oxygen cannula or oxygen mask. Some patients may require ventilation and oxygenation simultaneously.

When providing ventilatory support to a patient it is important to understand some common values. The total volume of air in each breath is known as the tidal volume. This is approximately 10 mL per kg. A 70 kg patient would have a tidal volume of 10 mL x 70 kg = 700 mL. Multiply the tidal volume times the respiratory rate to find the minute volume. In the 70 kg patient example, if the respiratory rate is 12 breaths per minute, the minute volume is 700 mL x 12 = 8400 mL minute volume or 8.4 liters per minute.

I. **THE BASICS** (Continued)

During the inspiratory and expiratory phases of respiration, pressures change within the lungs. At the beginning of the inspiratory cycle, pressure is at a minimum and continues to increase until a specific volume or a specific pressure is reached. When this volume or pressure has been reached, the expiratory cycle begins. The inspiratory time plus the expiratory time equals the complete respiratory cycle. The inspiratory time and the expiratory time are not the same and the relationship between the two is referred to as the inspiratory / expiratory ratio or I:E ratio. This ratio is typically 1:2 - 1:3.

In a patient breathing 12 times per minute, the total respiratory cycle time is 5 seconds (60 seconds divided by 12 breaths). The inspiratory portion of this cycle may only be 1.0 to 1.5 seconds with the remaining 3.5 to 4.0 seconds comprising the expiratory phase. Pressure and flow rates control the "I" time while exhalation flow resistance controls the "E" time.

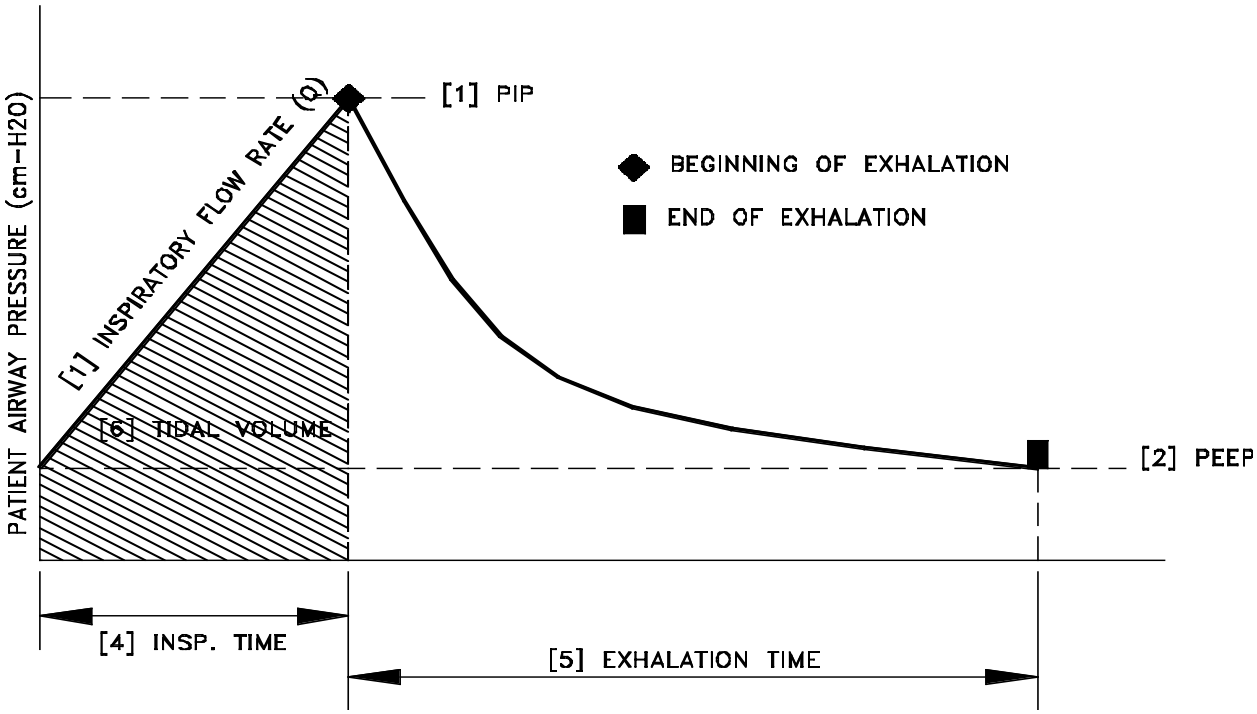
During the respiratory cycle, pressure within the lungs cycles from low to high. Factors that may affect the amount of pressure it takes to inflate the lungs are the presence of lung disease, obstructions and external pressures such as the presence of a pneumothorax. Without disease or mechanical factors, a patient's lungs will become fully inflated within the same pressure range irregardless of the size of the patient. This is an important concept as the same pressure range will be appropriate for most patients regardless of their physical size.

Typical pressures within the lungs range from 2 cm-H_2O and reach a peak of 18 - 25 cm-H_2O. This peak pressure of 18 - 25 cm-H_2O should provide adequate lung inflation in the majority of patients. You may have to increase this for diseased lungs, patients with asthma or in cases of chest trauma. The peak pressure is known as "Peak Inspiratory Pressure" or "PIP" and occurs at the end of the inspiratory cycle. This "PIP" will be a setting on pressure-cycled ventilators such as the SUREVENT.

At the end of expiration, the body naturally retains a slight pressure in the lungs known as "Positive End-Expiratory Pressure" or PEEP." This keeps the lungs from totally collapsing at the end of the respiratory cycle and makes it easier for the next breath. When using a ventilator, the operator will set an artificial PEEP to replace the natural PEEP.

I. THE BASICS (Continued)

FIGURE 1 -AIRWAY PRESSURE



[1] Peak Inspiratory Pressure (PIP) - Set by **PIP DIAL**, which controls INSPIRATORY TIME (I_{time})

[2] Positive End Expiratory Pressure (PEEP) – 10% of PIP setting

[3] INSPIRATORY FLOW RATE (Q) – Maximum 40 L/min (= 667 mL/sec)

[4] INSPIRATORY TIME (I_{time}) – Time required to reach PIP

[5] EXHALATION TIME (E_{time}) – Time required to drop from PIP to PEEP

[6] Tidal Volume = $Q \times I_{time}$

[7] RESPIRATORY RATE (RR) = $60 / (I_{time} + E_{time})$

[8] RATE DIAL – Set exhalation resistance and change RR

II. CURRENT METHODS OF PREHOSPITAL VENTILATION

In this section you will learn:

- Use of the BVM
- Risks associated with BVM use
- Benefits of controlling rate & volume

The majority of all prehospital ventilation is accomplished using the bag-valve-mask device (BVM.) This device has improved with the addition of colorimetric CO_2 monitoring and injection ports.
The BVM is an inexpensive, easy-to-use, dependable device for providing ventilatory support for breathing or non-breathing patients. When connected to an oxygen source and used in conjunction with a reservoir, the BVM can obtain oxygen concentrations of greater than 90%. In the event of electrical failure and/or loss of an oxygen source, the BVM allows continuation of ventilations on room air. The BVM is the mainstay of prehospital and emergency ventilatory support.

In the real world of emergency medicine, the BVM has limitations. The BVM requires a dedicated set of trained hands and the operator must be exactly synchronized with any and all patient movement. If the patient is receiving ventilations via mask, it is almost impossible to maintain an adequate seal during patient movement. If the patient is intubated, any significant movement of the BVM operator may result in an accidental extubation or right main stem intubation. During patient movement such as loading or unloading, the patient may not be ventilated at all! These all pose serious risks to the patient.

When ventilating a patient using a BVM, it is impossible to accurately control ventilation rate and volume. Even the best-trained hands cannot precisely control the rate and volume delivered. The rate and volume delivered directly affect the level of CO_2 in the blood and therefore blood chemistry. If ventilations are too slow or are inadequate, an elevation in CO_2 results. This in turn causes a drop in ph creating a state of respiratory acidosis. If ventilations are too rapid or have too much volume, this raises the ph and results in a state of respiratory alkalosis.

II. CURRENT METHODS OF PREHOSPITAL VENTILATION (Continued)

While hyperventilation and a decreased CO_2 is thought to be beneficial to a patient, primarily in head injuries and cardiac arrests, the effect is just the opposite. A state of respiratory alkalosis will cause a left shift in the oxyhemoglobin disassociation curve and impair the uptake and release of oxygen by the hemoglobin molecule.

FIGURE 2 - BVM

In an ill or injured patient, variations in the CO_2 level and blood chemistry can affect mortality and morbidity. It is vital that patients receiving ventilatory support are ventilated at a controlled rate and volume. With a manual device, this is not possible. The BVM is an acceptable alternative for very short periods of time or when no other device is available. If you have a choice, the ability to control rate and volume of gases delivered will benefit your patient and improve their outcome.

III. NEW METHODS OF VENTILATION

In this section you will learn:

- What makes a good pre-hospital ventilator?
- Benefits of the SUREVENT

In the prehospital setting, the BVM is the most widely used device for ventilatory support for many reasons. It is inexpensive, easy to use and there is little or no set-up time. In the prehospital care setting, there is no time or room inside a crushed car or on a shopping mall floor to set-up a ventilator. There have been some attempts at simplifying ventilators for use by prehospital care personnel, but most devices still have too many drawbacks.

III. NEW METHODS OF VENTILATION (Continued)

The ideal ventilator for prehospital care should have the following characteristics:

1. Provide reliable, consistent, and uninterupted ventilations
2. Requires minimal or no clean-up and maintenance at all.
3. Extremely simple to use –
4. Very short set-up time
5. Require little or no “calculations” for volume
6. Durable – EMS proof
7. Doesn’t bend, kink or pull on ET tube

The ideal ventilator would allow the prehospital provider to free up a set of hands, eliminate accidental extubations and maintain stable rate and volume in order to control CO_2 and blood chemistry levels. The advantages of using a ventilator far outweigh the BVM. A product well suited to the prehospital environment just did not exist until now.

A company in Sacramento, California in the late 1990’s developed a product, called the RespirTech PRO which was renamed the VAR for Vortran Automatic Resuscitator. This product is now marketed as the SUREVENT (FIGURES 3 and 4) and could quite possibly be the next step in prehospital ventilation. The SUREVENT is a lightweight, reliable, single patient use ventilator that is ideally suited for emergency medical services.

FIGURE 3 - SUREVENT WITH ET TUBE

FIGURE 4 - SUREVENT WITH MASK

III. NEW METHODS OF VENTILATION (Continued)

The SUREVENT is a pressure cycled automatic resuscitator that operates by sensing airway pressures. Unlike a volume cycle ventilator that requires you to calculate volume, the SUREVENT ventilates until a set pressure is reached. The SUREVENT is preset at 25 cm-H_2O which is adequate to ventilate most patients.

The SUREVENT will operate from a 50 PSI source and flow rates ranging from 15 liters per minute up to 40 liters per minute. Simply plug the connecting tubing to your regulator, turn the flow rate to 15 - 40 LPM, connect the SUREVENT to the patient, adjust pressure for chest rise and adjust the rate. It's done. The SUREVENT is supplied with a corrugated extension tubing that allows you to bend the resuscitator around and secure it next to the patient's head where it is easily accessible, yet out of the way during patient movement. An in-line manometer provides verification of ventilatory support and allows you to monitor airway pressures and respiratory rate.

IV. WHY USE AN AUTOMATIC RESUSCITATOR?

Why would you or should you switch from your trusty BVM to an automatic resuscitator? Good question. Medical research, innovations in medical technology and improved drugs continue to improve patient care and thus reduce mortality and morbidity. Numerous clinical studies clearly show the advantages of controlled ventilation in patients receiving respiratory support. Is EMS any different?

Even though it has been clinically demonstrated that automatic resuscitators offer improved patient care, size, complexity and cost have kept automatic resuscitators out of EMS in any great numbers. Sometimes the effort doesn't seem to be worth all the trouble. In an environment where there is increasing pressure to do more procedures in less time in the field, there is a need for cost effective, simple to operate technology that doesn't fall apart.

Here are the key clinical advantages of controlled ventilation:

1) Control of delivered volume or pressure
2) Control of delivered rate
3) Ability to administer PEEP
4) Control over oxygen and carbon dioxide levels
    a. Affects vasomotor status
    b. Affects pH
    c. Affects oxyhemoglobin disassociation curve by creating a left or right shift (decreased or increased affinity for and release of oxygen molecule)

Here are some key field / operational advantages:

1) Reduces personnel requirements
2) Improves quality of care and reduces risk to patient
    a. Reduced chance of extubation
    b. Uninterupted ventilations during movement

V. USE OF THE SUREVENT

(Refer to manufacturer's <u>Instructions for Use</u> for complete operating instructions)

The SUREVENT is ideal for any non-breathing patient you need to ventilate in the EMS setting including victims of cardiac arrest. The SUREVENT is not approved for patients under 40 kg of weight and therefore should not be used on pediatric patients.

You will need an oxygen source to operate the SUREVENT. Although you can operate the SUREVENT on 15 LPM, 25 LPM or greater is recommended. If you expect to have extended time away from your ambulance or helicopter, make sure your oxygen tank is full or you have a spare nearby.
The SUREVENT will NOT work without a pressurized air source!

The flow rate from your regulator will determine the "I" or inspiratory time. Oxygen flows through the SUREVENT and inflates the patients lungs. The rate at which this happens is dependent on the oxygen flow rate and the size of your patient. Although a flow rate of 15 LPM may work when you are trying to conserve oxygen, the I time will be extended. Increasing the flow rate to 25 LPM will shorten the I time because the increase in flow rate will decrease the time needed to inflate the lungs.

The RATE control knob determines the rate in which gas escapes from the breathing circuit by making an opening smaller or larger. This will determine the "E" expiratory time. Changes in "I" or "E" times will affect the overall respiratory rate. Flow rate determines I-time, the RATE knob determines E-time, together they control both the I and E time (respiratory cycle.)

Remove the SUREVENT from the package and connect one end of the oxygen tubing to your oxygen source and the other to the SUREVENT DISS fitting. Turn on the oxygen source and set flow rate to 25 LPM or greather (15 LPM if outside ambulance and you need to conserve oxygen.) Confirm you have gas flow through the resuscitator. Make sure all connections are tight, including piston, manometer, flex tube and oxygen tubing. Set Pressure setting to the 20 - 25 cm-H_2O range. Connect flex tubing from VAR to the endotracheal tube adapter (patient) and adjust PRESSUE control knob for chest rise.

V. USE OF THE SUREVENT (Continued)

Verify chest rise, bilateral breath sounds and overall patient appearance. Confirm with pulse oximeter readings and other vital signs. You can observe the rise and fall of the needle on the in-line pressure manometer.

Adjust the RATE control knob to 12 - 20 breaths per minute or adjust the rate based on end- tidal carbon dioxide levels of 35 - 40.

Always follow your local or EMS policies and procedures when you use this product or any medical device.

Once the PRESSURE and RATE are set, secure the SUREVENT to the side of the patient head to relieve the strain on the ET tube. During patient movement, consider placing a portable oxygen cylinder on the stretcher to minimize the chance of moving the ET tube. During patient use, continue to monitor your patient observing chest rise and fall, overall appearance and vital signs. Continue to make adjustments as needed to correct PRESSUE or RATE. **Never leave the patient unattended while on the SUREVENT.**

A kinked or plugged ET tube may cause the SUREVENT to flutter rapidly as the PIP is reached very quickly. Identify the cause of this problem immediately and correct it. A loose fittings or hose will cause a leak and the PIP may never be reached. If a leak prevents the SUREVENT from reaching PIP, the SUREVENT will never cycle. You must immediately identify the problem and correct it. If you are unsure what is wrong, immediately substitute the SUREVENT with a BVM and attempt manual ventilation.

The SUREVENT is easy to set-up and use even on the worst calls. Review the diagram of the SUREVENT and identify the various components. Set up and train with a test lung, There is a sample test included with this training guide (SectionVII - EMS EXAM.)

VI. TIPS FOR USING THE SUREVENT IN EMS

The SUREVENT is a simple to use, easy to set-up emergency transport ventilator that is ideally suited for EMS. Ventilators are not commonly used in EMS and may pose the fear of the unknown to many perspective users. Here are answers to frequently asked questions and concerns about the SUREVENT.

1) **It uses too much oxygen**.
   The SUREVENT can operate at 15 liters per minute, the same flow rate you use for bag-valve-mask resuscitators in providing high concentration oxygen. At 15 LPM you will notice a prolonged Inspiratory Time due to the lower flow rate. Confirm the patient's oxygen saturation and other vital signs. Whether you use the SUREVENT or a BVM, your field O_2 tank will last the same amount of time. Once your patient is in the ambulance or helicopter, turn up your oxygen flow to 25 liters per minute.
2) **I already have BVM's, why do I need a ventilator**.
   The SUREVENT provides constant, uninterrupted ventilations to your patient. This provides for consistent oxygen and carbon dioxide levels that translate into improved patient outcomes. It IS BETTER for your patient. Manpower resources can also be refocused on other patient care issues rather than bagging.
3) **It looks confusing.**
   The SUREVENT only has 2 settings:
   (1) PIP - that is adjusted for chest rise and;
   (2) Rate - that is adjusted to established standards or end-tidal CO_2 readings.
   The factory settings allow for immediate ventilations without any adjustments in most cases.
4) **When I intubate a patient, I will still have to open and use a BVM to check lung sounds.**
   Not true! You can immediately attach the SUREVENT to your ET tube to ventilate in order to check breath sounds.
5) **The SUREVENT is so inexpensive, can it really work?**
   Your right, the SUREVENT is inexpensive, but it is also reliable. The SUREVENT has been tested by flight crews, ground ambulance crews and hundreds of other EMS personnel. It works dependably while providing consistent ventilatory support to the sickest of patients.
6) **How do I know my patient is getting enough volume, there is no knob to set volume.**
   First of all, look at chest rise and your patient's vital signs. If you have adequate chest rise and your oxygen saturation and end-tidal carbon dioxide readings are within limits, your patient is doing fine. You and your patient are better off when you focus on the clinical basics, not on the equipment settings. The pressure ventilation will adequately ventilate the majority of patients unless the patient has a massive pneumothorax or major respiratory disease.

VI. TIPS FOR USING THE SUREVENT IN EMS (Continued)

7) **I really like to feel the "compliance" of my patient; I won't be able to do that anymore.**
   Small changes and trends often missed with BVM ventilations can now be quickly identified on the SUREVENT with changes in respiratory rate (BPM).
8) **When I disconnect the SUREVENT and reconnect to another oxygen source, it stops cycling**.
   This may occur if you go from a low oxygen flow to a high oxygen flow. When you increase the flow rate, you increase the minimum pressure inside the ventilator above the PEEP setting. If the pressure inside the ventilator remains above the PEEP setting, the ventilator will not cycle. To reduce the pressure, you must back off the RATE knob to reduce the pressure and start the SUREVENT cycling again.
9) **I don't know if our Paramedics are allowed to use a ventilator**.
   Check with your EMS agency as regulations vary from area to area. We think you'll find it is not a scope of practice issue with EMS authorities; it will be a training issue. Your local EMS agency, as well as the EMS provider, must be comfortable with the fact all EMS personnel that may use the SUREVENT have been trained to not only use it, but also to troubleshoot any situation that may arise during its use.
10) **Can the SUREVENT stay with a patient undergoing an MRI unit exam?**
    The SUREVENT can remain with the patient after you have delivered the patient to the hospital. If the patient is sent for an MRI exam, the Modulator (part with the two control knobs) and the Manometer should be separated from the patient "T" (part connected to the E.T. tube) by a 5' section of standard respiratory tubing. The oxygen source should also be away from the MRI as per the hospital protocols. Specify SUREVENT Model 2120 if you want a SUREVENT with the 5' respiratory extension tubing and the 20' oxygen supply tubing. A separate extension kit. Model 2173, containing the 5' extension tubing and the 20' oxygen supply tubing is also available.
11) **Why change**?
    Patient care has improved in and outside the hospital with the help of technology. Technology for the sake of being new is not worth adopting. Proven technology that can or will affect mortality and morbidity, reduce patient risks, and provide benefits for the healthcare provider deserve serious consideration by all.

VII. EMS EXAM

Name: _____ Department:_____

1) The SUREVENT is a:
   a. Volume Cycled Ventilator
   b. Pressure Cycled Ventilator
   c. Can Pressure or Volume Ventilate
   d. None of the above

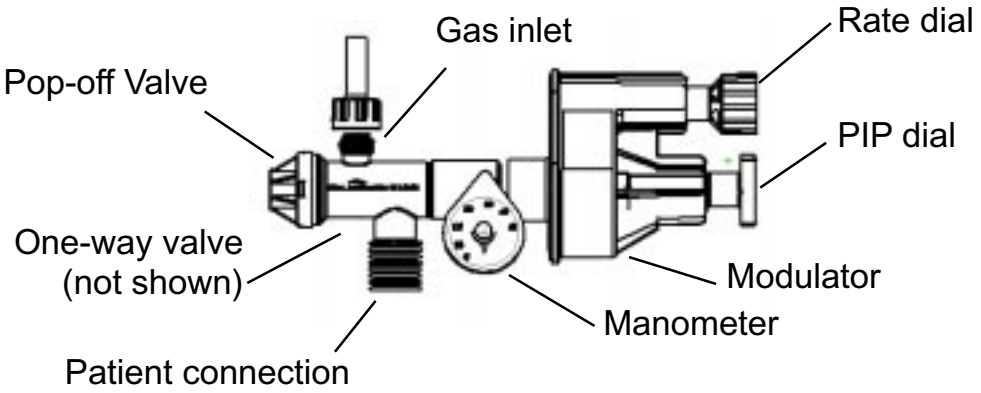
2) The typical pressure required to ventilate an adult patient is:
   a. 10 to 30 mm-Hg
   b. 20 to 30 cm-H_2O
   c. 10 to 20 cm-H_2O
   d. None of the above

3) The SUREVENT can operate on flow rates as low as:
   a. 15 liters per minute
   b. 40 liters per minute
   c. 5 liters per minute
   d. None of the above

4) The two control knobs on the SUREVENT are for:
   a. Rate and Volume
   b. Rate and PIP
   c. Pressure and PEEP
   d. PEEP and PIP

5) When setting the Peak Inspiratory Pressure (PIP) on the SUREVENT, PEEP is approximately:
   a. 10% of PIP
   b. 2% of PIP
   c. 20% of PIP
   d. None of the above

6) The inspiratory time or "I" time is controlled by:
   a. The rate control knob
   b. The PIP setting
   c. The flow rate of the gas source
   d. b and c



VII. EMS EXAM (Continued)

7) The pressure relief valves opens at what pressure?
   a. 25 cm-H_2O
   b. 45 cm-H_2O
   c. 60 cm-H_2O
   d. None of the above

8) IF the SUREVENT stops cycling, you should:
   a. Confirm you have oxygen connected and flowing
   b. Check for leaks in the system (O2 tubing, flex tube, etc.)
   c. Check for kinked or plugged ET tube
   d. All of the above

9) The pressure setting is adjusted based on:
   a. Adequate chest rise
   b. Normal oxygen saturation reading
   c. Normal end-tidal CO2 readings
   d. All of the above

10) The breathing rate setting is optimally adjusted based on:
   a. Established standards
   b. End-tidal CO_2 readings
   c. Oxygen saturation readings
   d. All of the above

11) When moving the oxygen source from 15 liters per minute to 25 liters per minute, you would expect to:
   a. Do nothing, the ventilator will not operate differently
   b. Be prepared to adjust the RATE knob to compensate for change in flow
   c. Be prepared to adjust the PIP knob for a change in pressure
   d. None of the above

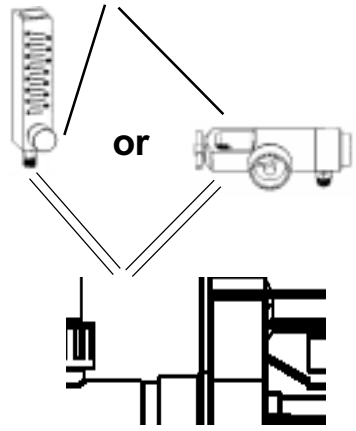
12) If a patient vomits into the body of the SUREVENT, you should:
   a. Pull it open, rapidly clean it and reassemble)
   b. Get another ventilator
   c. Continue to try to ventilate
   d. Call it quits and go home

Date: _____ Score:_____

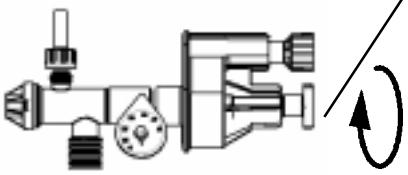
VIII. Quick Guide

SUREVENT Quick Guide

1 **Set flow to appx. 25 L/min**

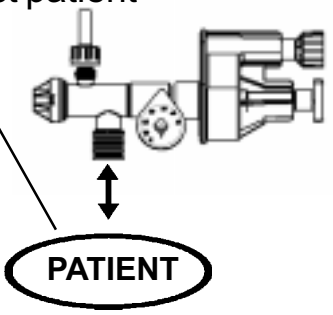


2 **Set pressure with PIP dial**
Verify 25 cm-H_2O

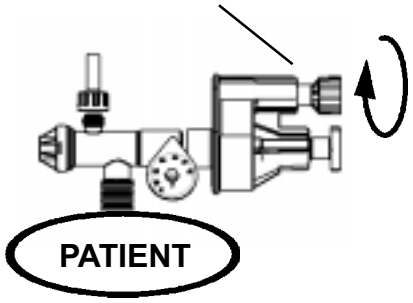


NOTE: Verify with a manometer

3 Connect patient



4 **Set breathing rate (BPM) with rate dial**



5 **Adjust Flow, PIP and Rate for patient's need.**

This Quick Guide is intended to help you gain a general understanding in the set up and use of the SUREVENT product. Please be certain to read, understand, and follow the information listed in this User's Guide before using this product.

MANUFACTURER:
VORTRAN Medical Technology 1, Inc.
3941 J Street, Suite 354
Sacramento, California 95819
TEL: (800) 434-4034
FAX: (916) 648-9751
Website http://www.vortran.com
E-mail: office@vortran.com

EMS DISTRIBUTOR:
Hartwell Medical Corp.
6352 Corte del Abeto # J
Carlsbad, CA 92009
TEL: (800) 633-5900
FAX: (760) 438-2783
Website http://www.HartwellMedical.com
E-mail: info@HartwellMedical.com

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EXAM ANSWER KEY

1. B
2. B
3. A
4. B
5. A
6. D
7. C
8. D
9. D
10. B
11. B
12. A