Ragged Edge Solutions Blog Post #3

SAVeII™ - SAVE Who?

In this post, I would like to discuss various capabilities and limitations of the SAVeII™ ventilator. My perspective comes from having 21 years of FRONT-LINE advanced training and experience working with and teaching mechanical ventilation and airway management at a level one trauma center in Eastern North Carolina. For the past eight months I have had the privilege of working with various military special ops medics providing didactic and hands on training specific to the SAVeII™.

SAVeII™ is a trademark belonging to AutoMed$_x$, Inc. For purposes of this post I am going to reference the SAVeII™ Operation Manual **Document Version** M40100 Rev 4.0 (07/16); Firmware Version R1.0.4.

"Remove the guesswork and reduce the operator error" pg.10

The device overview introduction on page 10 of the operator manual starts by saying "The SAVe™ II is designed to be used in lieu of a Bag Valve Mask (BVM) in the pre-hospital environment or during inter-and intra-hospital transport. ***It is meant to remove the guesswork and reduce the operator error*** associated with BVMs and overly sophisticated transport ventilators." (italics & bold added for emphasis)

Providing Bag Mask Ventilation and Mechanical Ventilation is NOT a guessing game. The reduction of operator error is greatly enhanced when you have a working knowledge of your device capabilities and limitations and when you can aptly match those to your patients changing respiratory system needs.

I assume this statement in the operator manual is provided for legal reasons "It is important that this manual is read and understood in its entirety before operating the ventilator. ***Operating or servicing this device without a complete understanding of its characteristics may cause harm to the patient***...This manual describes how to operate and respond to the ventilator, but ***does not include instructions on how to respond to the patient."*** (page 4, italics and bold added for emphasis).

Here is largely where I take issue. Knowing how to operate and respond to the ventilator MUST go hand in hand with knowing how to respond to your patient. Maybe this is why on page 11 the manual states "Spontaneously breathing patients may not synchronize with ventilator. Consider discontinuing use if a spontaneously breathing patient has difficulty..."

Think about the times when you may have been involved in an intubation or placement of an artificial airway. Placing an et tube through a set of vocal cords is easy when the preparatory tasks of positioning, pre-oxygenating, pre-medicating are done to match the patient's clinical needs. It is dangerous to separate your understanding of how a mechanical ventilator works from how a patient breaths. Placing a patient on a ventilator can at times be like throwing a dart into the wind at a moving bullseye. Patient -Ventilator Synchrony is paramount to success.

Providing effective and safe mechanical ventilation requires the continuous assessment of four items and how these items are interconnected. I will list these four times in the form of a mnemonic.

MOVE:

1. **M** - Mechanics of Breathing: has to do with spontaneously breathing patients and the muscles that are being used. How fast is the patient breathing (Respiratory Rate)? How deep is the patient breathing (flow demands)? What muscles are being used (Work of Breathing)? The other part of "M" is mental status. Think about Neural timing. What is the patient's mental status? Is the patient's mental status altered leading to an irregular respiratory pattern or rhythm?
2. **O** - Oxygenation: in the field, you will need to depend on assessment findings such as pulse oximetry, heart rate, skin color, level of sensorium to further assess your patient's oxygenation status.

3. **V** - Ventilation: in the field, you will depend on assessment findings such capnography (etCO2), chest rise and fall, symmetry of chest wall expansion to assess your patient's ventilatory status.
4. **E** – Equipment and Evaluation. You will continuously evaluate your efforts and the equipment you are using to make sure your patients work of breathing (WOB), mental status, oxygenation, and ventilation are stable.

"Operating or servicing this device without a complete understanding of its characteristics may cause harm to the patient…" (pg4 operators manual)

Let's use facts from the user manual to apply our understanding of the SAVeII™ to our understand of the MOVE mnemonic.

Mechanics of breathing and mental status have everything to do with rate, depth, and timing of a patients breathing pattern.

1. Max flow rate that can be delivered is 24Lpm (pg. 47)
2. I:E ratio is fixed at 1:2 (pg. 47)
3. Respiratory Rate Range 8-30 (pg.47)

Can these fixed ranges match your patients rate, depth, and timing of breathing when he is taking spontaneous breaths?

1. No- Adult males generate peak inspiratory flows of 30-40Lpm.
2. No- All people have varying inspiratory efforts. Think about sighs, shallow breathing, etc.
3. Yes- Normal adult RR is 12-20.

What are the potential consequences of the vent not meeting a patient's flow demand or matching a patients timing (breathing pattern)?

1. Patient ventilator dyssynchrony
2. Breath stacking
3. Barotrauma (pneumothorax)
4. Increased oxygen consumption
5. Increased carbon dioxide production
6. Reduced vent support (there is a built in one-way valve in-line with the circuit close to where it connects to the patient). This one-way valve opens allowing ambient air to fill the patient's lungs when the patient's own inspiratory flow exceeds the 24Lpm max flow the machine is able to generate.

Oxygenation is primarily going to be improved on this vent with the application of supplemental oxygen and PEEP (Positive End Expiratory Pressure)

1. Supplemental oxygen can be added at a flow rate of 1-10 Lpm with the ability to deliver 21%-100% fiO2.
2. PEEP can be set from Zero to 10 cmH2O.
3. Oxygenation can also be improved with prolonging the inspiratory time. This cannot be done directly since the machine has a fixed I:E ratio.

What are the limitations to how supplemental oxygen and peep are delivered?

1. The ability to deliver a precise fiO2 to a patient requires the absence of spontaneous breathing.
2. In order to deliver supplemental oxygen, you must connect a flexible piece of corrugated tubing to the air intake port on the ventilator. This corrugated tubing acts as a reservoir in which you hook a small piece of oxygen tubing to. The corrugated tubing fills with supplemental oxygen. The corrugated tubing can be expanded (or stretched) so that is can hold more oxygen. When the ventilator delivers a breath all the air needed to deliver the breath is pulled from this corrugated tubing. If the patient is breathing spontaneously and his efforts open the one-way valve then 21% fiO2 will be entrained and dilute whatever supplemental oxygen is being delivered.
3. PEEP maxes out at 10cmH2O.

Ventilation is primarily going to be managed via the set tidal volume and set Respiratory Rate on this vent.

1. The SAVeII™ supports minute volumes of up to 8 LPM (pg. 27)
2. Respiratory Rate Range 8-30 breath per minute (pg. 47)
3. Tidal Volume range 200 – 800 ml's (pg. 47)

What are the limitations to a max M.V. (Minute Volume) of 8 Lpm?

1. Minute Volume is calculated by multiplying RR (respiratory rate) times Vt (tidal volume). For instance, a RR of 10 x a Vt of 600ml's = 6000ml's per minute or 6 LPM.
   Normal M.V. for an adult male is 6-10 LPM.
2. The ranges for Vt and RR are misleading! The vent will not allow you to set any combination of RR x Vt that exceeds 8 LPM.
3. Any lung injury or hypermetabolic state is going to increase patients M.V. demands. It is not abnormal to have M.V. requirements close to 14 Lpm.
4. This vent advocates lower vt's based on Ideal Body Weight. Lower vt's lead to higher amounts of dead space. Dead space is air flow that does not participate in gas exchange (basically you will re-breath your carbon dioxide). The higher amount of dead space the higher your M.V. requirements will be. We should advocate a lower Vt approach for lung safety but in order to maintain an appropriate acid base balance we will need to deliver high M.V.'s.

Equipment and Evaluation is a continuous assessment and re-assessment of Mechanics of breathing, Oxygenation, and Ventilation. It's asking the question, "Is my ventilator optimized to match my patients need?" This is why I take issue with the statement on page 10 of the SAVeII™ operator manual that states "…It is meant to remove the guesswork and reduce the operator error associated with BVMs and overly sophisticated transport ventilators." Put this statement in context by also reviewing the statement on pg. 4 "This manual describes how to operate and respond to the ventilator, but does not include instructions on how to respond to the patient".

There are numerous limitations related to the performance of the SAVeII™. In my opinion if you don't have extensive experience in mechanical ventilation you will be more likely to put your patient in harms way by using the SAVeII™ as compared to mastering Bag Mask Ventilation. Either way, I support using the MOVE mnemonic as a systematic approach to BVM or Mechanical Ventilation.

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