



BIO-MED DEVICES' CROSSVENT 2+ NEONATAL THROUGH PEDIATRIC ICU & TRANSPORT VENTILATOR

by Joseph Sorbello RRT, M.Ed.

Readers may recall that the September 2005 issue of FOCUS contained a similar and very favorable equipment review of Bio-Med's newly-released CROSSVENT 3+® (CV 3+) by Mathews and Czervinske. Their review highlighted the newly-released color screen, battery improvements and software updates now implemented for all Crossvents.

Like its sibling, the CROSSVENT 2+® (CV 2+) is a direct descendant of the popular CROSSVENT 2 and a fine mechanical ventilator used by many across the nation. The first Crossvent was released in 1995 with the Crossvent 2+ released on January 16, 2007. This gem is designed as a neonatal-pediatric transport ventilator and is a member of a great family of mechanical ventilators with a myriad of capabilities (see Crossvent Comparison Chart below and at the Bio-Med website at: <http://www.biomeddevices.com/support/cvcomparison.html>. It can be used in both air and ground transport, in the ICU, for intra- and inter-hospital transport, in the sub-acute setting as well as the recovery room. The CV 2+ enhancements include a color display with a greater view angle and improved touch screen sensitivity, additional alarms including a Low Supply Pressure alarm, new and improved battery technology (6 plus hours) with a charging indicator and an improved user interface.

With the CV 2+, Bio-Med has again achieved its goal in its Crossvent series "...to pack as much as possible into a small, light weight package." This package is indeed small and lightweight. Its "foot print" is a diminutive 11" x 13.5" x 5.38". It weighs in at 9 lbs. (4.1 kg) or 12.5 lbs. (5.7 kg) with optional mounted blender. The package contains an impressive range of capabilities and features. It offers infant and pediatric ventilation modes, Assist Control (AC), Pressure Support (PS), Continuous Positive Airway Pressure (CPAP), Synchronized Intermittent Mandatory Ventilation (SIMV), and Pressure Limit. Sigh has been eliminated as in its sister, the CV 2i+.

Like its siblings, the CV 2+ employs a color LCD device with three touch sensitive screens to set and monitor four screens displayed as: MAIN, SEC (secondary), ALARM 1 and ALARM 2. The LCD panel displays text labels and numerical data only. It is easy to read with large displays of the numerical data of the patient's respiratory variables. During alarm conditions, the parameter which has been violated is highlighted and flashes during an

active alarm. As with the other Crossvent family members and as pointed out by Mathews and Czervinske, the absence of graphic waveforms is no criticism. This evaluator agrees with the fact that, during transport, numerical alarm and respiratory variables ARE much easier to recognize at a glance. None of the Crossvent user-therapists I spoke with found the absence of waveforms to be a negative. More from those experts later in this article. The one graphic/visual which IS worth displaying is the pressure bar graph to display airway pressure, thereby verifying circuit integrity and ventilator performance at a glance.

The touch screen is well-designed and requires just enough touch pressure to set the preferred parameter without worrying about making accidental changes. Spacing between the settings also makes accidental changes more difficult. The pneumatic functions, such as flow settings, maximum pressure and PEEP, mandate the turning of a knob. The screen is back-lit for comfortable and easy viewing under most conditions and the company even includes a feature where the backlighting can be turned off to save battery life – another thoughtful and important feature. However, turning off the backlight means no displays during the time the backlight is off. Alarm conditions will restore the backlight automatically, another good safety feature.

The front panel of the CV-2+ contains the LCD screen, the Max Pressure Control set knob, the PEEP set knob and the Flow control knob. Additionally, the front panel has an audible alarm speaker and an alarm LED, allowing full visualization of an alarm condition alert. The right side panel contains the Gas Supply Inlet, the Bleed Exhaust and a blender. The blender has a push-and-turn knob on the side for flow rates either greater than (pediatric) or less than (neonatal) 6 lpm. The left side panel has the Power On/Off Switch, External Power Supply Connector, LED Charging Battery Light, Pneumotach/Flow Sensor input, O₂ Sensor Connector, Exhalation Valve Connector, Airway Pressure Connector, Patient Gas Connector and Alarm Reset Switch. The rear panel has the Maximum Pressure (120 cm H₂O) Relief Valve and the Negative Pressure Relief Valve (machine shutdown occurs at – 4 cm H₂O). These are 3/4 inch, metal mesh-covered ports on the rear panel which must be kept free from obstruction. The specifications (control



Bio-Med Devices' Crossvent 2+

parameters and ranges) for each of the basic and advanced variables are listed below;

Parameter	Range
➤Rate	5-150 bpm
➤Tidal Volume	5 – 990 ml
➤Inspiratory Time	0.1 – 3.0 sec
➤Flow Rate	1 – 50 lpm
➤I/E Ratio	3:1 to 1:99
➤Peak Pressure	0 – 80 cmH2O
➤PEEP Pressure	0 - 20 cmH2O
➤Pressure Trigger	– 0.2 to – 10 cmH2O
➤Flow Trigger	1- 20 (sensitivity scale)
➤SIMV Rate	0.6 – 50 bpm
➤O2 Sensor	21 – 100%
➤Exhaled Tidal Volume	5 – 1300 ml

The MAIN screen displays rate (AC or SIMV), tidal volume, inspiratory time, expiratory time, I:E ratio, flow, pressure trigger, flow trigger, mode (AC, SIMV or CPAP manual), alarm quiet, and lock on or off.

The SEC (secondary) screen displays rate (AC or SIMV), tidal volume, inspiratory time, expiratory time, I:E ratio, flow, nebulizer enabled or disabled and pressure support. The nebulizer is disabled if the set flow rate is less than 20 lpm.

The CrossVent 2+ Neonatal through Pediatric ICU & Transport Ventilator is powered by a rechargeable NiMH battery with a 6 hour life. The LCD screen has a LCD charging indicator and a visually large Low Battery alarm. O2 is added via cylinders or by an optional O2 blender with a 3% accuracy rating. Power supply requirements are 31-75 psig, compressed, dry medical grade gas from cylinders or a piped source. If an air/O2 blender is used, 45-75 psig power to the blender must be used.

Electrical power is supplied by the internal battery which can be recharged using the Bio-Med 16VDC 3A charger/converter which also allows for AC operation. In addition to the above settings and controls, the CV 2+ incorporates the following alarms: Peak Pressure, Respiratory Rate, Oxygen and Low Battery. The CrossVent 2+ is also equipped with PEEP, Exhaled Tidal Volume (EHTV),

Mean Airway Pressure and Low Gas Supply alarms. When an alarm condition occurs, the parameter for the out of limit condition will flash red. If more than one alarm condition happens simultaneously, both LCDs flash red. All of the audible alarms are silenced when the Alarm Quiet key is activated. The Alarm Quiet Key, when touched once, invokes a 60 second audible pause. When touched twice it sets a 120 second audible silence condition. If a new alarm condition should occur during the silence the Alarm Quiet disengages and indicates the new condition. During alarm conditions the LCD screen "locks" on to the screen containing the controls and indicators for the current alarm condition. This can only be released by solving the problem or by touching the Alarm Quiet key. There is a "LOCK" control that disallows any parameter to be changed. Engaging the screen LOCK requires just one touch. Disengagement requires two touches.

Alarms are divided into a three tiered hierarchy; in tier 1 are the Primary Alarms and are indicated on the Alarm1 screen – Respiratory Rate, Peak Pressure and Exhaled Tidal Volume (EXHVT). EXHVT can be turned off if it's not used. Tier 2 alarms

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or Secondary Alarms, appear on the Alarm2 screen. These include PEEP, Mean Pressure and O2%. O2% and Mean Pressure can be switched off. Tier three alarms appear on the Alarm3 screen. These alarms and the Alarm3 screen only appear when the alarm condition exists. These alarms consist of the Low Gas Supply Pressure, Low Battery and Ventilator Failure Alarms.

During laboratory tests, the ventilator performed well with each test condition. It provided enough head (distal) pressure to prevent attenuation of the flow wave form when introduced to high impedance conditions, such as high resistance or low compliance. Clinically, the CV-2+ produced consistent flow rates during each breath sufficient for all test conditions. During high load periods, tidal volume delivery was consistent and within 40-50 ml of the target volume on a Michigan adult test lung. The control ventilation modes operated commendably and as predicted. During testing I kept within reasonable clinical ranges and did not reach the published limits on flow and pressure. This was related to test conditions/parameters and not a limitation of the ventilator.

Since the CV-2+ utilizes a threshold resistor/balloon type "Bennett" exhalation valve, it "honks" loudly as Mathews and Czervinske also found during high load conditions with PEEP. The solution was to pop the exhalation port cap off of the valve, which also serves to stream line the circuit. With the pneumotach in line, it was not necessary to measure exhaled tidal volumes at this port. I would doubt the accuracy of nearly any spirometer placed on the exhalation port to measure small tidal volumes, accurately,

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especially at high respiratory rates. During spontaneous breathing in SIMV and CPAP, the CV-2+ performed well and measured flow, pressure and volume measurements, were constant across all test conditions. I was unable to adequately measure the trigger response time and performance.

Each Unit Includes: O2 high pressure supply hose, pediatric circuit (disposable), infant circuit (disposable), infant/pediatric test lung, infant pneumotach and a pediatric pneumotach, infant test lung, oxygen sensor cell, standard 1 inch pole mount bracket, instructions/service manual.

The combined Operations and Service Manual provided to me was presented in a three ring binder containing 93 (8 1/2 x 11") pages printed single sided allowing plenty of room for notes and easy updating. Additionally, the manual came with a companion CD-ROM highlighting the entire CrossVent series including, of course, the Crossvent 2+. Both the Service and Operations portions of the manual were detailed and easy to read. The Manual consists of nine sections and 7 appendices plus a comprehensive table of contents and an alphabetized index. The graphics in the manual are clear and easily legible. Forty-three pages of the manual are devoted to Operations and the remainder to Service.

Testing and evaluation in a laboratory are one thing and valuable. However, testimonials from actual users are another and, to this author and hopefully to you the consumer, just as important when evaluating a ventilator for purchase. To this end, I contacted users of the CrossVent 2+ Neonatal through Pediatric ICU & Transport Ventilator and other Crossvent

mechanical ventilators who use them exclusively for out of hospital transport. I asked for their honest evaluation of the Crossvent 2+ and the Crossvent family of ventilators, if they had such experience. This is what they had to say (permission from all was granted to use their comments for this article).

Mike Harmon MHPE, RRT, Manager of Clinical Education Standards for PHI Air Medical, Inc., based in Phoenix AZ but traveling extensively throughout the U.S., describes the Crossvent 2+ as "being a durable, reasonably priced mechanical ventilator that meets all of our basic ventilatory needs. We are very happy with this ventilator, have no issues with it at all, with problems being rare and service excellent!"

Jerry Focht RRT, NREMT, CMTE is the Chief Flight Respiratory Therapist for Northwest Medstar in Spokane WA. He describes the Crossvent 2+ as "dependable, light, easy to operate.....we receive very good company support and these ventilators work well despite all the rough treatment they receive in our challenging work environment."

Roger Jundos, RRT is the Pediatric Clinical Coordinator at Peyton Manning Children's Hospital at St. Vincent in Indianapolis IN. He says that, "The CV 2+ is reliable, durable and very easy to use. When I have a patient on it, I don't have to worry about them. I know that my patient is safe."

Transport of patients, particularly those as fragile as infants and children, is a tough business and requires a durable, accurate and capable machine that is also simple. One of the many variations of the KISS acronym proclaims: Keep It Simple & Safe, which is – appropriately – taken from those in airline and aviation management. This author's evaluation and the testimony of its everyday users are in agreement. The CrossVent 2+ Neonatal through Pediatric ICU & Transport Ventilator is an excellent choice as a transport ventilator. Its small, compact size and light weight, combined with its ease of use, excellent and consistent function in high load conditions without sacrificing performance plus a very reasonable purchase price (\$7,000 range) put it high on the list of mechanical ventilators that you'll want to have for your neonatal and pediatric transport needs. Mirroring Mathews and Czervinske comments: I like the versatility and predictability of this ventilator and I highly recommend that you examine it closely if you're in the market for a transport ventilator. Bio-Med Devices, Inc. is an excellent company, well-respected and has a long & proven track record in this business. They are known for excellence in education and customer service as well. See their website at: www.biomeddevices.com, or call them at 1-800-224-6633.



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