COMPETENCY MATERIAL

FOR

Gas Operated Vent®

AUTOMATIC RESUSCITATOR

ELG Medical - Brockhurst Industrial Estate, Gunners Way, Gosport, PO12 4DR, United Kingdom
| +44(0)2392 534 930 | info@elgmedical.co.uk | www.elgmedical.co.uk |

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Gas Operated Vent®
(Automatic Resuscitator)
Benefits & Features

HIGHLIGHTS

- Automatic pressure cycled, hands-free ventilation
- Disposable, single patient use
- Safe for MRI/CT scan when extension tubing is used and New Manometer is certified MRI Conditional
- Easy to set-up and use
- New Entrainment Control allows change from 50% to 100% FiO_2 during operation

APPLICATION

- Inter-facility, intra-facility transports
- ER or ICU, replacing manual resuscitators (bags)
- Hyperbaric chamber
- MRI or CT procedure
- Emergency back-up ventilation for hospitals and alternative care facilities
- Disaster management or field hospital

COST SAVING

- Eliminates capital equipment expenses
- Reduces labor intensity associated with manual resuscitators (bags)
- Substantial cost-savings compared to automatic resuscitators and transport ventilator
- No maintenance and repair expenses
- Save rental cost on ventilator
- Save therapist time for getting and setting up ventilator for short-term use

CONVENIENT

- Easy to store - no large ventilator to take up limited ER/ICU space
- Quick set-up and easy operation with no clean-up costs or recycling time required
- No missing pieces of ventilator when needed
- Flexible usage with mask or endotracheal tube
- Use in-line with HME and/or HEPA filter
- New Easy 1,2,3 set up labeling allows for ease of use when setting Gas Operated Vent® up on patient

RELIABLE

- High pressure pop-off safety valve reduces potential of pneumothorax
- Technology minimizes gas trapping to reduce the potential for barotrauma

SAFETY

- Eliminates the potential need for a new set of ventilation tubing
- Eliminates the need for a manual resuscitator and/or additional ventilation
- Frees up the RT's & EMT's hands to perform other critical functions
- Ideal for use with chest compression

Gas Operated Vent® Automatic Resuscitator Competency Trainer Copy	
Set the Gas Operated Vent® in pressure control mode.	As long as you have a set rate, you are in the pressure control mode.
Demonstrate the ability to set rate and pressure settings and to estimate delivered tidal volume.	Use Tidal Volume Table on package insert to help you determine tidal volume or multiply flow in mL/second by the inspiratory time in seconds.
PEEP is intrinsic to this device. Please explain how intrinsic peep is estimated on the Gas Operated Vent®.	PEEP is 1/5th of your set peak pressure (PIP) for the Gas Operated Vent®.
What are the maximum and minimum flow rates that can be achieved with the Gas Operated Vent®?	If set to deliver 100%, the minimum flow is 10 L/min and the maximum is 40 L/min. If set to deliver 50%, the minimum flow is 6 L/min and the maximum is 15 L/min. Remember 50% mode connector provides room air entrainment; set flow 6 L/min ⇒ 20 L/min, 8 L/min ⇒ 25 L/min, 10 L/min ⇒ 30 L/min, 12 L/min ⇒ 35 L/min, 15 L/min ⇒ 40 L/min.
The Gas Operated Vent® is set at 50% with a set supply flow of 10 L/ min. What is the total flow being delivered to the patient?	30 L/min.
Can you set a constant respiratory rate and tidal volume with the Gas Operated Vent®?	No
Does patient compliance have a direct effect on respiratory rate and volumes being delivered from the Gas Operated Vent ®?	Yes
Connect test lung to the Gas Operated Vent® to simulate patient and observe cycling. Adjust flow rate for desired inspiratory time.	Increased flow = shorter inspiratory times Decreased flow = longer inspiratory times
Set mandatory respiratory rate (RR) by adjusting RATE dial, count BPM.	Turn RATE dial clockwise (inward) = slower rate and counter clockwise (outward) = faster rate.
Troubleshooting the Gas Operated Vent®	
When adjusting the RATE dial on the Gas Operated Vent®, it sometimes stops cycling. What is happening?	RATE dial is turned too far in the *clockwise* direction putting the Gas Operated Vent® in spontaneous mode. Turn RATE dial *counter* clockwise until the Gas Operated Vent® self-cycles.
During a transport, my rate setting changed even though my patient is sedated and not breathing spontaneously. What can cause this to happen?	Change in lung compliance, mucus plugs, pulmonary edema, or any other condition making the lungs harder to ventilate.
While on the Gas Operated Vent® my patient is breathing spontaneously and I hear this loud vacuum sound that coincides with his spontaneous breathing. What is happening?	Patient inspiratory demand is greater than the flow being delivered by the Gas Operated Vent®, patient is breathing room air through the one-way valve. If this occurs you may want increase your set flow to the Gas Operated Vent®.
After completion of the Gas Operated Vent® Competency, the Practitioner should be able to setup the Gas Operated Vent® for transport and be able to troubleshoot problems that may arise in its use.	

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Setting up the Gas Operated Vent® For Training

CAUTION: Follow instructions and warnings on the package insert before using the Gas Operated Vent® devices.

1 Gas Operated Vent® Model #6123:

- 100% or 50% FiO_2 Delivery:

2 Items used for training:

- Gas Operated Vent®
- Instruction Insert
- Oxygen Tubing
- Gas Source
- Test Lung

3 Connect to a 50 PSI gas source using an oxygen cylinder with regulator.

- Screw oxygen tubing supplied to the outlet of your gas source.

4 Alternatively, connect to a flow meter from wall gas outlet.

- Flushing your wall outlet flow meter will deliver maximum of 40 LPM.

5 If 100% FiO_2 is to be delivered to the patient, connect tubing to the white gas connector with the DISS thread connection on the patient tee. Ensure that the green knob is turned clockwise until it comes to a stop.

6 If 50% FiO_2 is to be delivered to the patient, connect tubing to the white gas connector with the DISS thread connection on the patient tee. Ensure that the green knob is turned counterclockwise until it comes to a stop.

Setting up the Gas Operated Vent® For Training

7 Turn on gas and listen to the gas flow. Flush the flow meter from your wall outlet to deliver 40 LPM, if needed.

8 Connect test lung to the Gas Operated Vent® patient port to simulate patient.

- Observe cycling in the modulator or manometer.

9 The Gas Operated Vent® will deliver FiO_2 of 50% (±10%) when the green knob is turned all the way counterclockwise and is supplied with oxygen flow from 6 to 15 L/min with resulting output flow of 20 to 40 L/m respectively.

10 Adjust flow rate for desired inspiratory time (***I-Time***).

- Increased flow = shorter ***I-Time***
- Decreased flow = longer ***I-Time***

11 Adjust Peak Inspiratory Pressure (PIP) by turning the rectangular PRESSURE dial.

- Verify PIP with a pressure manometer.

12 Set controlled respiratory rate (RR) by adjusting round RATE dial. Count breaths per minute (BPM) manually:

- **Slower Rate** = Turn dial clockwise (inward)
- **Faster Rate** = Turn dial counter clockwise (outward)

13 Because the Gas Operated Vent® is pressure cycled, changes in the patient's lung compliance will cause a change in the patient's breathing rate. In such an event, make the appropriate clincial changes.

NOTE: The Gas Operated Vent® is positional sensitive. Final rate adjustments should be made with the device in its secured operating position.

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Facility Name Here – State of _____

Gas Operated Vent® Automatic Resuscitator
COMPETENCY CHECKLIST

EMPLOYEE NAME:_____DATE:_____

This form is used for initial training of new staff and for annual competency evaluation of employees. This analysis of job competency should be made at the work site where the actual procedure is performed.

INSTRUCTIONS TO THE OBSERVER / CERTIFIED TRAINER: Observe the above named employee in the performance of the indicated procedures. Directly observe the employee performing the procedures as listed below. For each procedure that conforms to the Gas Operated Vent® testing procedure, place a checkmark in the "acceptable" column. If any procedure is performed incorrectly, place a checkmark in the "unacceptable" column and give instructions for corrective action in the comments section.

	PROCEDURE	ACCEPTABLE	UNACCEPTABLE
1	Has read the Gas Operated Vent® guidelines.		
2	Demonstrates proper storage of the Gas Operated Vent®.		
3	Demonstrates setting the Gas Operated Vent® in pressure control mode.		
4	Demonstrates setting rate, pressure setting, and estimating delivered tidal volume.		
5	Able to connect test lung to the Gas Operated Vent®, simulating patient to observe cycling conditions.		
6	Able to adjust flow rate for desired inspiratory time (shorter I-Time = increased flow & longer I-Time = decreased flow).		
7	Demonstrates setting mandatory respiratory rate by adjusting RATE dial.		
8	Able to verbalize maximum & minimum flow rate achieved with the Gas Operated Vent®.		
9	Able to verbalize how intrinsic peep is estimated with the Gas Operated Vent®.		

COMMENTS:_____

_____

_____

EMPLOYEE SIGNATURE_____DATE_____

TRAINER SIGNATURE_____DATE_____

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Guidelines for Safe Use of the Gas Operated Vent® Automatic Resuscitator

DESCRIPTION:

The gas powered Gas Operated Vent® provides constant flow and pressure cycled ventilatory support to both breathing and non-breathing patients, in either pressure control or pressure support modes. The device includes a pulmonary modulator (an exhalation valve that opens at PIP and closes at PEEP), a patient connector tee to supply gas flow, and provides a redundant pop-off valve set at 60 cm-H_2O. Spontaneously breathing patients may entrain ambient air.

INDICATIONS:

This device is to be used by properly trained personnel to deliver emergency, short term, pressure cycled, and constant flow ventilatory support. This allows the patient to receive consistent and reliable, hands-free, ventilatory support.

PROCEDURE:

STEPS	KEY POINTS / RATIONALE
1. Remove the Gas Operated Vent® from package and connect oxygen tubing to a gas source.	
2. Select FiO_2 a. When 100% FiO_2 delivery is desired for patient: b. When 50% FiO_2 delivery is desired for patient:	Set FiO_2 based on the patient's requirements. – Connect tubing to the white gas connector with the DISS thread connection on the patient tee. Ensure that the green knob is turned clockwise until it comes to a stop. – Connect tubing to the white gas connector with the DISS thread connection on the patient tee. Ensure that the green knob is turned counterclockwise until it comes to a stop.
3. Select desired tidal volume, I-Time, and flow.	Refer to Tidal Volume Table that is supplied with the Gas Operated Vent® or calculate.
4. Adjust PRESSURE dial to achieve desired peak pressure.	Indicated pressures are approximate and may vary depending on conditions and settings. Verify with a manometer. For use with a mask, clear mouth and airway of visible foreign bodies and use accepted techniques to ensure correct position of airway. Hold mask firmly against face while keeping head positioned. For use with endotracheal tube, connect patient adapter directly to endotracheal tube.

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PROCEDURE (Continued):

STEPS	KEY POINTS / RATIONALE
5. Adjust RATE dial to achieve desired respiratory rate.	The Gas Operated Vent® may enter into a spontaneous "pressure assisted" mode (mandatory rate stops) when adjusting the RATE dial clockwise or with changing conditions. To return to automatic cycling, rotate the dial counterclockwise until the desired mandatory rate is achieved.
6. For further instructions, refer to the User Manual.	The User Manual and User Support Documentation is supplied with the Gas Operated Vent®.
7. Refer to the User Manual Cautions and Warnings prior to utilizing the Gas Operated Vent®.	
8. Users of the Gas Operated Vent® may have documented current CPR training, and have completed the competency checklist and test to complete Gas Operated Vent® training.	Refer to the Gas Operated Vent® Training Competency Checklist and Exam (attached).

APPROVED BY: _____ Medical Director

_____ Medical Director

_____ Director of Respiratory & Neurophysiology Services

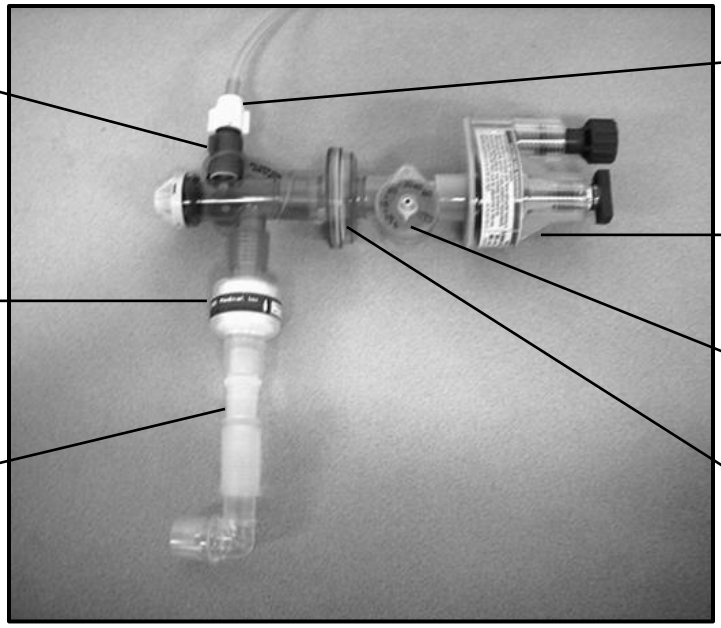
EFFECTIVE DATE: _____ **REVIEWED**: _____

SUPERSEDES: _____

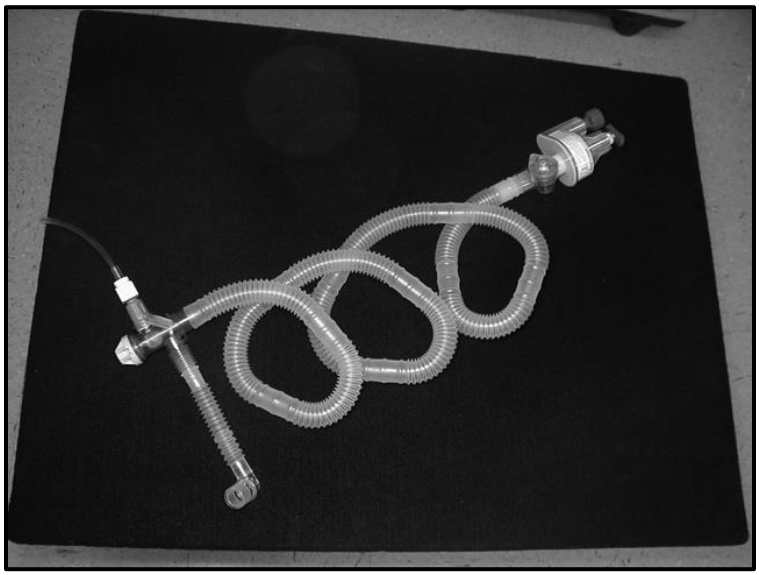
REFERENCES: _____

PREPARED BY: _____

AR® (Automatic Resuscitator) with HME/ HEPA Filter Configuration for all Models



AR® (Automatic Resuscitator) MRI/CT Scan Set-up for all Models



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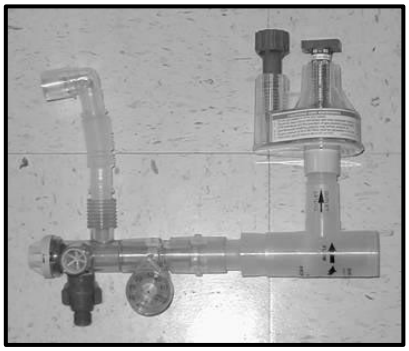
“Additional” In-Line PEEP Set-up for PEEP Valve

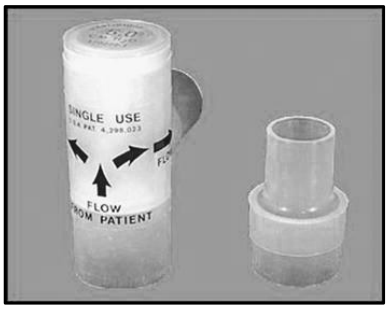
The PEEP (Positive End Expiratory Pressure) is **intrinsic** in the AR® (Automatic Resuscitator). About 10% of the patient’s PIP (Peak Inspiratory Pressure) is PEEP (20% in the AR-Plus Model PCM). For example, if the patient is set to PIP of 30 cm-H_2O, PEEP is about 10% of PIP = 3 cm-H_2O). For additional PEEP, the in-line PEEP valve can be used with any AR® models.

IMPORTANT:

a. Follow PEEP valve flow direction (you may have to use additional connectors 22 mm OD M-M or F-F)
b. Most PEEP valves come in 2.5 cm increments. If using a 5 cm-H_2O PEEP valve, remember the patient PIP and PEEP will both be evaluated (for example, if the patient’s pressure setting is set at 30 PIP over 3 of PEEP, add 5, now 35 over 8 cm-H_2O).



Most Recommend In-Line PEEP Valve Used with AR® Devices



ORDERING INFORMATION		
Code	**Description**	**Per Case**
9003B	ACCU-PEEP™ Valve 2.5 cmH_2O*	10
9005B	ACCU-PEEP™ Valve 5.0 cmH_2O*	10
9007B	ACCU-PEEP™ Valve 7.5 cmH_2O	10
9010B	ACCU-PEEP™ Valve 10.0 cmH_2O	10
9012B	ACCU-PEEP™ Valve12.5 cmH_2O	10
9015B	ACCU-PEEP™ Valve 15.0 cmH_2O	10
9022B	ACCU-PEEP™ Valve 20.0 cmH_2O	10
9005A	PEEP Valve Adapter	10

*The most commonly used in-line PEEP Valve with the AR® Devices is 2.5 and 5.0

For more information, contact Vital Signs, Inc. at (800) 932-0760 or visit their website at: vital-signs.gehealthcare.com

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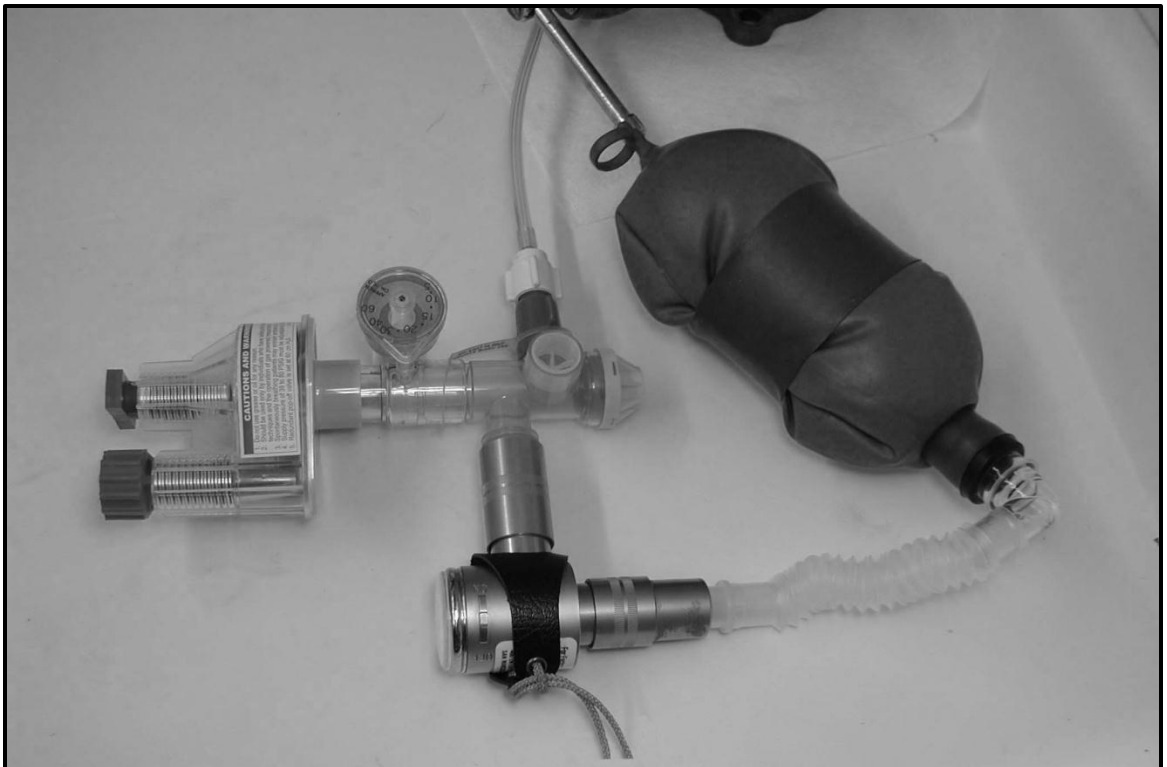

"INHALATION" – Measurement reading is an estimate only due to continuous flow during inhalation & exhalation.

"EXHALATION" – Measurement reading is an estimate only due to continuous flow during inhalation & exhalation.

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The Automatic Resuscitator - AR-Plus™ is ideal with changing compliance

The Automatic Resuscitator (AR) is not a time-cycled ventilator and will respond automatically to changes in compliance, as seen in Acute Respiratory Distress Syndrome (ARDS). The AR self-adjusts by increasing respiratory rate (RR) and decreasing tidal volume (TV) and delivers a stable minute ventilation (MV) when compliance decreases from a healthy 0.07 to a stiff 0.02 L/cm H_2O (Figure 1 & Figure 2). This is recommended by the ARDS Network's publication, funded by the National Heart and Lung Institute, which showed a 22% lower mortality with low TV ventilation strategy in patients with ALI or ARDS.[1] The AR automatically delivers a lower TV and a higher respiratory rate (RR) and is ideal for ARDS patients with decreasing compliance.

INTRODUCTION

AR-Plus (Model PCM) is the latest breakthrough in the family of disposable automatic resuscitators. It meets and exceeds ASTM guidelines for automatic resuscitators (F 920 – 93) for patients with a body mass of 10 kg and above.[2] The unique feature of the AR family of products is its ability to respond to changing compliance at any selected pressure setting. Because the AR cycles at a settable PIP with intrinsic PEEP, the constant ΔP (Delta-P is the difference between PIP and PEEP) produces a reduced TV at a higher RR as compliance decreases.

METHODS

The Test and Training Lung (TTL, Model 3600i, by Michigan Instruments, Inc.) with PneuView Software was used in the bench top evaluation of AR-Plus (Model PCM-5011). An in-line PEEP valve (Model BE 142, by Instrumentation Industries, Inc.) was used to elevate the PEEP from the baseline. The AR-Plus was initially set to deliver approximately 800 mL TV for a patient with a compliance of 0.07 L/cm-H_2O by adjusting the PIP, intrinsic PEEP and inspiratory flow to achieve a respiratory rate of 10 BPM and I/E ratio of 1:2. After establishing the initial setting, the compliance setting on the TTL was steadily

Table 1 – Results of AR-Plus with and without in-line PEEP Valve at Set PIP

COMPLIANCE (L/cm-H_2O)	PIP	17.2		PIP	21.0		PIP	26.5	
	PEEP	5.1		PEEP	9.7		PEEP	14.9	
	ΔP	12.1		ΔP	11.3		ΔP	11.6	
	BPM	TV	MV	BPM	TV	MV	BPM	TV	MV
0.07	11.5	815	9.4	8.0	855	6.8	10.2	794	8.1
0.06	13.4	671	9.0	9.1	722	6.6	12.1	675	8.2
0.05	16.4	532	8.7	11.4	590	6.7	14.1	564	8.0
0.04	20.7	402	8.4	14.2	451	6.4	17.1	445	7.6
0.03	27.9	285	7.9	18.6	316	5.9	22.0	318	7.0
0.02	41.9	178	7.5	28.1	197	5.6	31.7	204	6.4

The AR-Plus™ is ideal with changing compliance

decreased by 0.01 and the AR-Plus was left untouched. Changes in TV, RR and the resulting MV were recorded, at each compliance setting, for a PEEP of 5, 10 and 15 cm-H_2O.

DISCUSSIONS

The AR automatically delivered a reduced tidal volume (TV) at a faster respiratory rate (as shown in Figures 1 and 2) from a healthy 0.07 to a stiff 0.02 L/cm H_2O setting, maintaining the low TV ventilation protocol as recommended by the ARDS Network. Without making any adjustments on the AR-Plus, it will deliver a stable minute ventilation (MV = TV X RR) as shown in Figure 3.

CONCLUSIONS

The ARDS Network study found a 22% lower mortality in acute lung injury and ARDS patients who were ventilated with lower tidal volumes than in those ventilated with traditional tidal volumes ventilation.[1] The AR-Plus automatically delivers a lower TV at a higher rate and is ideal for ARDS patients with decreasing compliance.

REFERENCES

[1] Kallet, Richard H MS RRT: Implementation of a Low Tidal Volume Ventilation Protocol for Patients with Acute Lung Injury or Acute Respiratory Distress Syndrome. Respir Care 2001:46(10):1024-1037.

[2] Designation: F 920 – 93 (Reapproved 1999) An American National Standard. Standard Specification for Minimum Performance and Safety Requirements for Resuscitators Intended for Use With Humans.

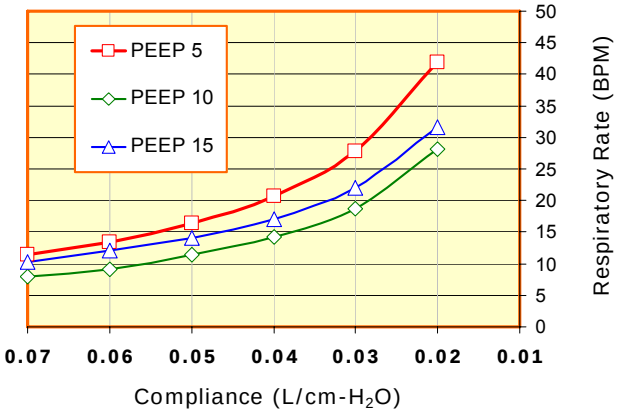

Figure 1
Rate Automatically Changes
with Changing Compliance

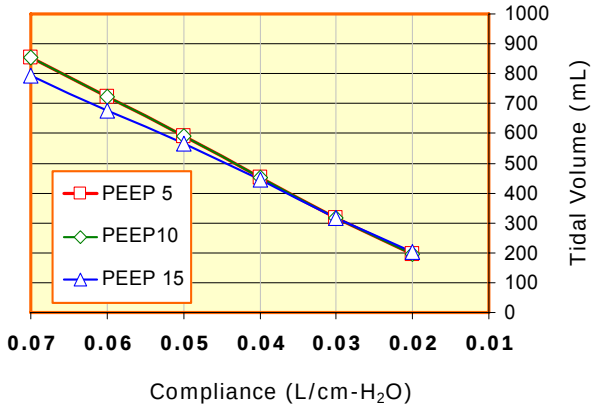

Figure 2
TV Automatically Changes
with Changing Compliance

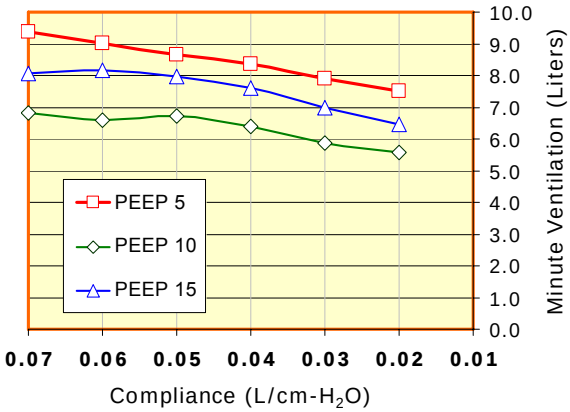

Figure 3
Delivered Minute Ventilation (MV)
with Changing Compliance

The AR Is Positional Sensitive

The Automatic Resuscitators (AR™) will function in any position as long as the adjustments are made in a secured position (strapped or taped to the patient). Tilting movements of less than 45° have no significant effect on the PIP setting. The working mechanism of the AR consists of a moving piston or diaphragm which has mass (weight). The mass adds an additional spring force or a subtraction of spring force when the AR is positioned with the modulator vertically up or vertically down. If the AR is moved from a horizontal to a vertical position, the addition or subtraction of spring force will affect the PIP setting by 1 to 3 cm-H_2O. The positional effect on PIP is an educational and training issue. [1]-[2] The AR will function in any position as long as the final adjustments are made in its secured position.

INTRODUCTION

The Automatic Resuscitators (AR™) are pneumatically driven, flow controlled devices unlike the conventional electro mechanical ventilators. The AR modulator functions like a piston or a diaphragm system which cycles at PIP and PEEP. The cycling thresholds are controlled by a spring force on the piston or diaphragm. Because the piston, diaphragm and spring have mass, the position of the modulator, relative to the vertical direction, causes an increase or a decrease in the set PIP setting as the modulator is rotated. Because of this effect, final adjustments to the VAR's modulator should be made in the restrained position. However, it is of interest to know how much the set PIP pressure changes as the modulator is rotated.

METHODS

Three each of the AR-Plus (PCM-5011) and AR (RCM-4011) from the production lots were selected for bench top evaluation using the Test and Training Lung (TTL, Model 3600i, by Michigan Instruments, Inc.) with PneuView Software. Each device was setup initially with the modulator in the vertical up position (Fig-2) with the I/E ratio set to approximately 1:2. The PIP data was recorded. The device was then rotated to position the modulator horizontally (Fig-1), and the resulting PIP was recorded. The modulator was then turned to the down position (Fig-3), and the final PIP was recorded.

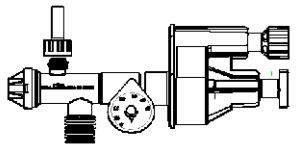

Figure 1
Modulator in the horizontal position

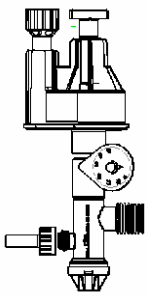

Figure 2
Set PIP with Modulator in the vertically up position

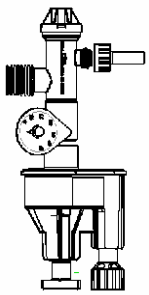

Figure 3
Rotate Modulator to vertically down position

The AR Is Positional Sensitive

The initial PIP targets, with the modulator in the vertical up position, were 45, 40, 35, 30, 25, 20, 15 and 10 cm-H_2O for the AR-Plus and 45, 40, 35, 30, 25 and 20 cm-H_2O, for the AR-RCM. This yielded a matrix of PIP and PEEP values from which the pressure change from the horizontal position could be calculated.

RESULTS

Table 1 – Results of AR-Plus Set PIP

Device	PIP with Modulator positioned horizontally	PIP increase Modulator in the vertically up position	PIP decrease Modulator in vertically down position
AR-Plus (PCM)	44	1.1	-1.1
	39	1.0	-1.0
	34	1.2	-0.9
	29	1.1	-0.8
	24	1.1	-0.9
	19	1.1	-0.9
	14	1.0	-1.0
	9	0.8	-1.0
	AVG	1.0	0.9
AR (RCM)	43	2.1	-3.1
	38	2.2	-3.0
	33	2.7	-2.9
	28	2.4	-2.9
	23	2.6	-2.7
	18	2.6	-3.0
	AVG	2.4	-2.9

The averaged PIP for the horizontal position are listed in Table 1. The changes in pressure when the device is rotated from vertically up and to vertically down are calculated from PIP recordings, and the results illustrate the gravitational effect on the modulator components and the resultant effect. Table 1 show that the AR-RCM does have PIP change effects of up to 3.1 cm-H_2O when the device is rotated from horizontal up or down. The AR-Plus exhibits significantly less positional sensitivity with a change of up to 1.1 cm-H_2O. This is a result of the improved diaphragm modulator design.

CONCLUSIONS

Although the AR experiences PIP setting changes of 1 to 3 cm-H_2O when the device is moved, the impact should be significantly less than the inconsistencies that occur during manual resuscitation with a Bag-Valve-Mask (BVM).[3]-[4] The positional effect on PIP is an educational and training issue. [1]-[2] Users need to know that the AR will function in any position, as long as final adjustments to the device are made after it has been positioned securely. The manufacturer of the AR is continuing to improve the design and function of the AR and is making every effort to reduce the changes in the PIP setting.

REFERENCES

[1] Babic M, Branson R, Stoller J. Evaluation of the SureVent Emergency Transport Ventilator (abstract). Respir Care 2005(50):1531.

[2] Auble TE, Menegazzi JJ, Nicklas KA. Comparison of automated and manual ventilation in a prehospital pediatric model. Prehosp Emerg Care 1998;2:108-111.

[3] Silbergleit R, Lee DC, Blankreid C, McNamara RM. Sudden severe barotrauma from self-inflating bag valve devices. J Trauma 1996;40:320-322.

The Flow Characteristics of E-Vent Case™ Manifold System

INTRODUCTION

During the national statewide disaster drills, many health care facilities realized the finite limit of ventilators determines the number of patients that can be managed in any mass casualty incident (MCI). Under the Hospital Preparedness program, the bureau awards grant money to states who allocate, to as many hospitals as possible within the designated regions, to strengthen the ability of hospitals and other health care facilities to respond to bio-terror attacks, infectious disease outbreaks and natural disasters that may cause MCI. [1]

It is recognized, that the Automatic Resuscitator (AR™), a pneumatically driven automatic resuscitator, provides the best clinical options as to location (not all triage sites have A/C power), portability, relative ease of use and the most cost effective way of providing basic mechanical ventilation to a large number of patients.

Packaging the ARs in the E-Vent Case (Figure A), with all your emergency procedures and supplies, allows for rapid emergency ventilator deployment in any MCI.

The E-Vent Case™ gas distribution manifold system is engineered specifically for operating multiple ARs from a single gas source (oxygen, compressed air or oxygen enriched air). For added robustness while operating in the field, the manifold is mounted on a sturdy stand. The manifold inlet is connected to the gas source via a twenty foot (20') heavy duty oxygen hose. The supplied gas pressure is adjustable using the manifold mounted pressure regulator and pressure gauge. Each of the seven (7) outlets is fitted with male thread oxygen DISS fitting with auto shut off. The manifold system can support up to seven ARs operating from the single gas source. The AR is a completely pneumatic driven resuscitator that runs on a continuous flow of compressed gas. Typically, hospital supplied gas is regulated to 50 PSIG and the system is capable of providing sufficient flow to meet the demand of medical equipment.

Figure A - E-Vent Case™ packages with the ARs

[1] Health Resources and Services Administration (HRSA). HRSA works to fill in the health care gaps for people who live outside the economic and medical mainstream. The agency uses its $7.4 billion annual budget (FY 2005) to expand access to quality health care for all Americans through an array of grants to state and local governments, health care providers and health professions training programs. HRSA'S Special Programs Bureau provides $660 million in programs and services.

However, in the emergency situation, with limited resources, preparing for an emergency means knowing the capacity and limits of your facility. Understanding your gas supply is essential in determining the numbers of surge capacity ventilator patients the facility can manage. The ARs and E-Vent Case offer tools to help you meet your needs but it is not the complete solution. You also need trained clinicians and sufficient gas resources. This report details the flow requirements and operational characteristics of the ARs using the E-Vent Case manifold system. Using the flow requirement information provided herein, there are many alternative gas distribution systems that the hospital's biomedical department can develop to achieve the same result To safely and effectively operate multiple ARs from a single gas source, make sure your gas distribution can provide the flow (liters per minutes) to meet the demand.

SETTING UP THE MANIFOLD

Setting up the E-Vent Case manifold distribution system for multiple ARs is easy. Follow the five quick steps [1] – [5]:

Step: [1] Connect to a gas source. Connect the other end of tubing to manifold inlet (Figure B).

[2] Set patient flow to 25 LPM with pressure gauge at 25 PSIG (Figure C).

[3] Connect patient (Figure D).

[4] Adjust PIP and rate for patient's needs (Figure E).

[5] Verify PIP with a manometer

Figure B - Manifold is connected to source gas via a 20' tubing

Figure C - Set manifold pressure using the regulator and pressure gauge

Figure D - Connect patients

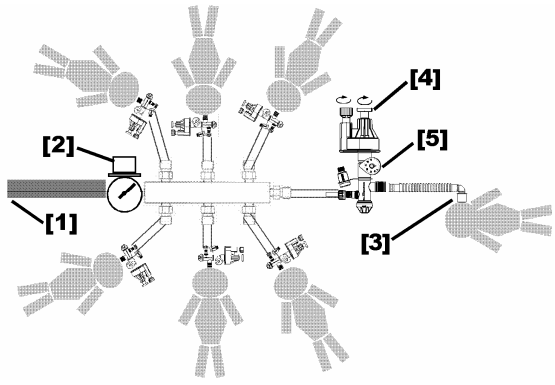

Figure E - Adjust PIP and rate

METHODS OF EVALUATION

The E-Vent Case manifold system is connected to a compressed air source using the twenty foot (20') oxygen hose supplied. This bench top evaluation was conducted using the following two (2) scenarios:

i. When the gas source supplied is capable of maintaining a constant 50 PSIG pressure to the manifold
ii. When the gas pressure supplied is limited to maximum of 50 PSIG

In each scenario, ***i*** and ***ii***, the AR is operated in both the [***A***] 100% FiO_2 mode and in the [***B***] 50% entraining mode to simulate oxygen consumption. In both cases, compressed air (21% FiO_2) is used and flow rate is measured. The density of the oxygen compared to the density of room air makes an insignificant difference in the flow measurements herein. At each pressure setting, flow from each individual AR is recorded and summarized in Tables ***A1***, ***B1***, ***A2*** and ***B2***.

Table *A*1 – AR is operated in the 100% FiO_2 mode with green colored connector when manifold pressure is set to 50 PSIG

No. of ARs connected to manifold		***1***	***2***	***3***	***4***	***5***	***6***	***7***
Supplied source pressure	(PSIG)	51	52.5	55	58	62	67	73
Total flow requirement	(LPM)	**42**	**83**	**125**	**166**	**208**	**249**	**291**
Averaged flow to each AR	(LPM)	42	41.5	41.6	41.5	41.6	41.5	41.6

Table *B*1 – AR is operated in the 50% FiO_2 mode with grey colored connector when manifold pressure is set to 50 PSIG

No. of ARs connected to manifold		***1***	***2***	***3***	***4***	***5***	***6***	***7***
Supplied source pressure	(PSIG)	50	50	51	51	52	53	54
Total flow requirement	(LPM)	**16**	**31**	**47**	**62**	**78**	**93**	**109**
Averaged flow to each AR	(LPM)	16	15.5	15.6	15.5	15.6	15.5	15.6

Table ***A*1** indicated the maximum flow of 291 LPM when operating 7 ARs in 100% mode. This requires the source pressure to be at 73 PSIG in order to maintain a 50 PSIG manifold pressure. Although this is not common, due to regulated hospital source gas pressure, it demonstrated that the manifold can deliver maximum flow to 7 ARs. Table ***B*1** indicated the flow demand is significantly less when operating in entrainment mode.

Table *A*2 – AR is operated in the 100% FiO_2 mode with green colored connector when supplied source pressure is set to 50 PSIG

Nos of ARs connected to manifold		***1***	***2***	***3***	***4***	***5***	***6***	***7***
Manifold pressure	(PSIG)	49	47	45	43	40	37	34
Total flow requirement	(LPM)	**41**	**79**	**114**	**147**	**173**	**196**	**214**
Averaged flow to each AR	(LPM)	41	39.5	38	37	34.5	33	30.5

Table *B2* – AR is operated in the 50% FiO_2 mode with grey colored connector when manifold pressure is set to 50 PSIG

Nos of ARs connected to manifold		***1***	***2***	***3***	***4***	***5***	***6***	***7***
Manifold pressure	(PSIG)	50	50	49	49	48	47	46
Total flow requirement	(LPM)	**16**	**31**	**46**	**61**	**75**	**89**	**102**
Averaged flow to each AR	(LPM)	16	15.5	15.3	15.3	15	15	14.5
Delivered flow w/entrainment	(LPM)	~40	~40	~40	~40	~40	~40	~40

When the supplied source pressure is regulated to 50 PSIG, adding or removing ARs to the manifold will result in a pressure drop as indicated in Table ***A2***. When operating all 7 ARs from a 50 PSIG gas source, the maximum flow available to each AR will be 30 LPM. The pressure drop in the entrainment mode as shown in Table ***B2*** is significantly less with a lower flow demand and maximum flow can be delivered for up to 7 ARs.

CONCLUSIONS

The E-Vent Case manifold system demonstrated that it can sustain up to 7 ARs operating simultaneously. The key is to understand the supply pressure capability of the gas source (compressed air or oxygen). It is critical for each facility to evaluate the gas supply system in order to prepare for any surge capacity incidents[1, 2, 3].

When connected, all patients on the same manifold system will receive the same amount of flow (LPM) regardless of their individual clinical situation. Any adjustment made on supply pressure will affect all patients connected to the manifold and flow is estimated to be within ±15% (see Table 3).

Table 3 - Estimate delivered flow rate (LPM) for each patient

Delivered flow	Set manifold pressure	
	100% FiO_2	50% FiO_2
20 LPM	25 PSIG	10 PSIG
25	30	20
30	40	30
35	45	40
40	50	50

REFERENCES

1. Donald G. McNeil Jr., Hospitals Short on Ventilators if Bird Flu Hits, New York Times, March 12, 2006.

2. Dan Hanfling, MD, Equipment, Supplies, and Pharmaceuticals: How Much Might It Cost to Achieve Basic Surge Capacity? Acad Emerg Med Volume 13, Number 11 1232-1237, published online before print June 26, 2006.

3. Frederick M. Burkle, Jr., MD, MPH, Population-based Triage Management in Response to Surge-capacity Requirements during a Large-scale Bioevent Disaster. Acad Emerg Med Volume 13, Number 11 1118-1129, published online before print October 2, 2006.

Evaluation of the Automatic Resuscitator and the Airway Pressure Monitor in the MRI Environment

A. Berthieaume, Dave Swift RRT

Introduction: The magnetic resonance imaging (MRI, 3 Tesla strength) scanner creates a unique electromagnetic environment that allows high fidelity images of patients. With critically ill patients requiring mechanical ventilation, this environment produces some unique challenges in management of ventilation and monitoring of ventilation. Currently, there are a limited number of ventilatory devices that can provide mechanical ventilation in the MRI environment.

Methods: To determine if the Automatic Resuscitator (AR Plus model) can be safely utilized in the MRI environment. To evaluate, if the Airway Pressure Monitor (APM) can deliver accurate monitoring capability within the MRI environment. The AR-Plus performance was verified in a bench top setting, within the MRI core (with and without extension lines) and outside of the MRI core (with and without extension lines). The APM was used in parallel to verify the AR-plus performance.

Results: The AR-plus consistently delivered the RATE (within one bpm) and pressure set using a static lung compliance & resistance model. The APM unit consistently monitored the set rate. However the unit's ability to monitor the inspiratory time was limited by its design characteristics of only displaying the inspiratory time by rounding up at the 0.05 mark (ex. Ti of 0.56 displays as 0.6 and 0.45 displays as 0.4). The APM (Airway Pressure Monitor) is not designed to be used within the immediate magnetic field of the MRI machine. The magnetic field interferes with its operation and the authors recommend that it not be used within that magnetic field – it does provide effective remote monitoring capability for the AR-plus.

Conclusion: The AR-plus can effectively function, according to established performance characteristics, within the MRI environment. The unit is not impacted by the electromagnetic field of the MRI scanner. The APM provides an effective remote monitor for ventilation within the MRI environment (outside of the magnetic field) for adult and pediatric populations not requiring very low inspiratory times.

Proposal: Verify the AR (Automatic Resuscitator) performance under the following conditions:

- reaction to MRI while in the core (no extension line)
- reaction to MRI while in core (with extension line)
- reaction to MRI while just outside of core (with extension)
- reaction to MRI while just outside of core (without extension)

Verify the AMP (airway pressure monitor) performance, used with the AR, under the following conditions:

- pressure accuracy before and after MRI exposure
- reaction to MRI while AR in the core (no extension line)
- reaction to MRI while AR in core (with extension line)
- reaction to MRI while AR just outside of core (with extension)
- reaction to MRI while AR just outside of core (without extension)

Evaluators: Alain Berthiaume, MRI Charge Technologist, Ottawa Hospital; Dave Swift RRT, Campus Coordinator & Charge Respiratory Therapist Ottawa Hospital.

Equipment: AR-plus (AR plus extension kit) product PCE 5012 & PTE 5002; TEST LUNG model VTL-3600; Airway Pressure Monitor -3800/pediatric model IP31; MRI: Siemens TIM TRIO, software version V17.3 tesla magnet, TQ-engine (45mT/m@200T/m/s); Draeger C500 Infinity

Manometer: Baumanometer BP Manometer with noncompliant tubing (W.A. Baum Co Inc, Coplague, NY, USA).

Verification of the Airway Pressure Monitor 3800/pediatric model IP31

Bench Top Test: Using an in-line manometer & the C500 ventilator as the controller the displayed data was compared (ventilator, manometer vs APM)

Parameter	C500 ventilator	Manometer	APM (6 inch extension line)
RATE	20	---	19
	24	---	23
	30		29
	40		39
	50		50
	60		59 high rate alarm
PEEP	3 cm H2O	2.1 mmHg (2.85 cm H2O)	3 cm H2O
	5 cm H2O	3.7 mmHg (5.03 cm H2O)	5 cm H2O
	7.5 cm H2O	5.3 mmHg (7.20 cm H2O)	7 cm H2O
	10 cm H2O	7.4mm Hg (10.06 cm H2O)	10 cm H2O
Inspiratory Time (Ti seconds)			
	0.3 sec	--	0.3 sec
	0.35 sec	--	0.3 sec
	0.40 sec	--	0.4 sec
	0.45 sec	--	0.4 sec
	0.50 sec	--	0.5 sec
	0.56 sec	--	0.6 sec

In operator control room of MRI no performance changes noted using AR equipped without extension tubing compared to bench top verification.

Verification of the Airway Pressure Monitor 3800/pediatric model IP31 in operator control room of MRI with AR equiped with extension tubing

Parameter	C500 ventilator	APM
RATE	20	18
	24	23
	30	29
	40	39
	50	49
	60	58 high ratealarm
PEEP	3 cm H2O	3 cm H2O
	5 cm H2O	5 cm H2O
	7.5 cm H2O	7 cm H2O
	10 cm H2O	10 cm H2O
Inspiratory Time (Ti seconds)		
	0.3 sec	0.3 sec
	0.35 sec	0.3 sec
	0.40 sec	0.4 sec
	0.45 sec	0.4 sec
	0.50 sec	0.5 sec
	0.56 sec	0.6 sec

Automatic Resuscitator – Performance verification (Outside of MRI core)

Parameter	Set value*	Bench test		
(non-MRI environment)	MRI with extension line	MRI without extension line		
RATE	10 bpm	10 bpm	9 bpm	10 bpm
	12	12	11	12
	20	20	19	20
	30	30	29	29
	40	40	39	40
	50	50	48	49
	60	60	58	59

Automatic Resuscitator – Performance verification (Inside of MRI core)

Note: the VTL-3600 test lungs contained steel screws as part of its assembly and it was effected by the magnetic core and required support to complete the test.

Parameter	Set value*	Bench test		
(non-MRI environment)	MRI with extension line	MRI without extension line		
RATE	10 bpm	10 bpm	9 bpm	10 bpm
	12	12	11	12
	20	20	19	20
	30	30	28	29
	40	40	38	40
	50	50	47	49
	60	60	59	59

*set value set prior to entry to MRI, unit set & then disconnected from gas source and reconnected in MRI.
50psi direct connection, no flowmeter used.

Conclusion

The ar-plus functions within its designed/specified parameters within the MRI environment. The AR-plus is a pneumatically powered, continuous flow, pressure cycled, expiratory time limited automatic resuscitator that can provide effective ventilation to a patient within the MRI. As with all pressure cycled devices, changes in lung compliance and resistance can alter the rate and delivered lung volumes. For patient who may undergo dynamic changes in their resistance and compliance the use of the APM is essential.

The APM is a small, portable monitoring device that displays the inspiratory time, respiratory rate, inspiratory pressure and intrinsic peep on a continuous basis. It provides a high pressure, high rate, and fail to cycle alarms in either an adult or pediatric configuration. The APM is not designed to function within the established gauze field and the authors recommend that the optional extension line be used when used within the MRI environment.

The Control of End Tidal CO2

Robert Kohler, EMT-P

Introduction

Pre-hospital care can be defined as efforts to achieve or maintain homeostasis. The ability to monitor and control CO2, a key component of the buffering system, is an essential means to that end. Because CO2, a key component of the buffering system, has a direct effect on the pH of the body, the ability to monitor and control End Tidal CO2 (ETCO2), is essential in order to maintain homeostasis.

Recently the American Heart Association has issued new guidelines defining a narrow range of optimal oxygen saturation for many situations. Based on these recommendations proper patient care mandates that we have the ability to control both components of ventilation. This pilot study examines the feasibility of controlling the End Tidal CO2 during 911 ground ambulance operations.

Materials and Methods

There were 2 ventilation adjuncts available, the choice of either was not defined or dictated by the protocol and was the clinician's choice.

The control: an adult bag valve mask (BVM) as manufactured by Life Support Products #L770 with a bag volume of 1488 ml, valve dead space of 7.8 ml (not including mask) and a patient connection of 22 mm outside diameter, 15 mm inside diameter with no pop off valve.

The study: An oxygen powered disposable PIP cycled automatic resuscitator that regulated: Respiratory Rate, Tidal Volume, Peek Inspiratory Pressure (PIP). Peak End Expiratory Pressure was variable at 20% of the selected PIP. The AR-Plus model PCM (Automatic Resuscitator) was used.

In December of 2009 Stamford EMS Paramedics began a program of training using manufacturer's competency requirements and guidelines from the FCCS course curriculum. Clinical targets were FiO2 of 100% at a rate of 10-12bpm and a PIP range from 20-25cm/H2O. Paramedics were not restricted to these targets and were instructed to vary settings to meet the patients' needs.

ETCO2 was monitored via Side-Stream filter line Capnography as manufactured by Microstream and available on the Lifepak 12s currently in use.

January through September of 2010, 152 intubated patients were reviewed. 46 met the criteria of any patient greater than 10 kg with an intrinsic pulse and in respiratory arrest whether idiopathic or clinician induced as an example from Rapid Sequence Induction. One patient was excluded due to a metabolic aberration. The remaining cases were split, with 1,012 specific ETCO2 samplings evenly distributed over 23 cases using a BVM (as the control) and with 1,270 specific ETCO2 samplings evenly distributed over 22 cases using the AR. The first 4 minutes of data records from all cases were excluded to compensate for procedural anomalies experienced while securing the airway.

Data for all cases in each group were combined for the calculation of standard deviation (Sd). The Sd was also calculated for each individual case. The difference in the quantity of records had no statistical significance on results in a test analysis.

Results

After 9 months, ETCO2 values in the control group reflected a Standard deviation of 16.97 while the test group ventilated with the AR reflected a standard deviation of 14.09. In addition the test group trended lower as time progressed while the control group did not.

Conclusion

Although data is still being collected, these initial values show that despite the dynamic environment of the pre hospital setting, with a minimum of additional training the pre-hospital provider can more accurately control ETCO2 with a disposable PIP cycled respirator than with a Bag Valve Mask.

Sources

- Stamford Emergency Medical Services – Stamford CT.
- Fundamentals of Critical Care Support fourth edition – Society of Critical Care Medicine
- Lifepak 12 as manufactured by Physio-Control Inc. – Redmond WA.

The author is with Stamford Emergency Medical Service, Stamford, CT.

Gas Powered Gas Operated Vent® Automatic Resuscitator for Short Term, Emergency Ventilation

Exam (Page 1 of 2)

1) The Gas Operated Vent® Automatic Resuscitator is a:
    a. Volume controlled ventilator
    b. Pressure cycled ventilator
    c. Time cycled ventilator
    d. None of the above

2) The typical pressure required to ventilate an adult patient is:
    a. 10 – 30 mm-Hg
    b. 25 – 30 cm-H_2O
    c. 10 – 20 PSIG
    d. None of the above

3) The maximum flow for the Gas Operated Vent® at a typical 50 PSIG supply pressure is:
    a. 15 liters per minute
    b. 40 liters per minute
    c. No limit
    d. None of the above

4) The two control knobs on the Gas Operated Vent® are for:
    a. Rate and Volume
    b. Rate and PIP
    c. Volume and PEEP
    d. PEEP and PIP

5) When setting the Peak Inspiratory Pressure (PIP) on the Gas Operated Vent®, PEEP is approximately:
    a. Unrelated to PIP
    b. 50% of PIP
    c. Approximately 10% to 20% of set PIP
    d. None of the above

Gas Powered Gas Operated Vent® Automatic Resuscitator for Short Term, Emergency Ventilation

Exam (Page 2 of 2)

6) The inspiratory time or "I-Time" is controlled by:
   a. The flow rate of the gas source
   b. The pressure (PIP) setting
   c. Patient's compliance
   d. All of the above

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 Gas Operated Vent® stops cycling, you should:
   a. Confirm you have oxygen connected and flowing
   b. Check for leaks between gas supply and patient
   c. Back out the Rate dial
   d. All of the above

9) The PIP pressure setting should be adjusted based on:
   a. Adequate chest rise
   b. Normal oxygen saturation reading
   c. Normal end-tidal CO_2 readings
   d. All of the above

10) The 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

Gas Powered Gas Operated Vent® Automatic Resuscitator for Short Term, Emergency Ventilation

Answers to Exam

1) The Gas Operated Vent® Automatic Resuscitator is a:
   b. Pressure cycled ventilator

2) The typical pressure required to ventilate an adult patient is:
   b. 25 – 30 cm-H_2O

3) The maximum flow for the Gas Operated Vent® at a typical 50 PSIG supply pressure is:
   b. 40 liters per minute

4) The two control knobs on the Gas Operated Vent® are for:
   b. Rate and PIP

5) When setting the Peak Inspiratory Pressure (PIP) on the Gas Operated Vent®, PEEP is approximately:
   c. Approximately 10% to 20% of set PIP

6) The inspiratory time or "I-Time" is controlled by:
   d. All of the above

7) The pressure relief valves opens at what pressure?
   c. 60 cm-H_2O

8) If the Gas Operated Vent® stops cycling, you should:
   d. All of the above

9) The PIP pressure setting should be adjusted based on:
   d. All of the above

10) The rate setting is optimally adjusted based on:
    d. All of the above

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