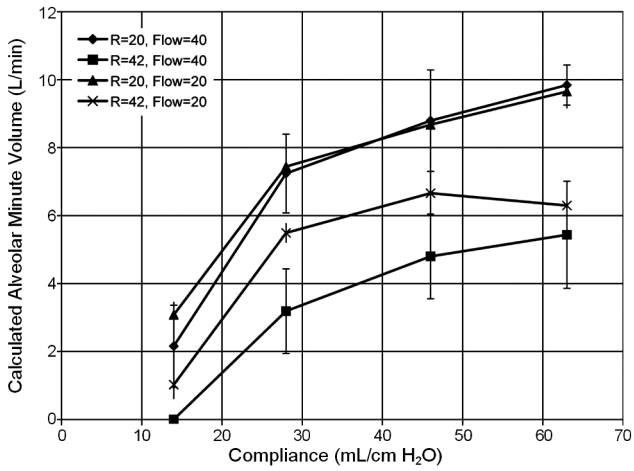

Fig. 2. Calculated alveolar minute volume versus lung compliance for each of the 4 combinations of airway resistance (R) and set device flow with the Vortran Automatic Resuscitator. The error bars represent one standard deviation. All the measurements were done with the device set at the lowest indicated maximum inspiratory pressure of 20–30 cm H_2O. The figure shows a drop in calculated alveolar minute volume due to expected decreasing tidal volume and compliance associated with high respiratory rates (> 40 breaths/min). (All data in this figure are from Table 2 in Reference 1.)

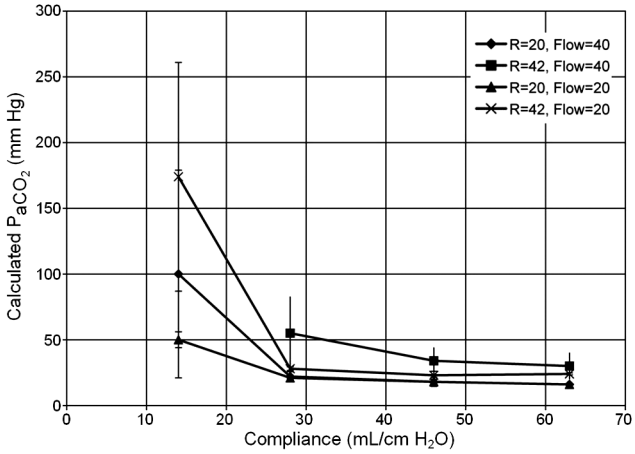

Fig. 3. Calculated P_{aCO_2} versus lung compliance for each of the 4 combinations of airway resistance and set device flow with the Vortran Automatic Resuscitator. The error bars represent one standard deviation.[1] All the measurements were made with the device set at the lowest indicated maximum inspiratory pressure of 20–30 cm H_2O. The figure shows that the device was able to provide sufficient ventilation, provided that the tidal volume was not too low (the predictable result of a low maximum-inspiratory-pressure setting of 20–30 cm H_2O and a compliance of only 14 mL/cm H_2O). (All data in this figure are from Table 2 in Reference 1.)

As Babic et al correctly stated, it is important that the Vortran Automatic Resuscitator be used under the supervision of a trained clinician who can evaluate the appropriateness of the settings and make adjustments as needed to the operating conditions to optimize the respiratory conditions to the patient's needs. In patients with severely limited lung compliance and/or high airway resistance, higher MIP may be indicated and a higher pressure setting can be used than the low setting that Babic et al chose in their study, and in the worst cases an auxiliary PEEP controller may be desirable.

S David Piper PE
Piper Medical
Carmichael, California

S David Piper PE works for Piper Medical and is the inventor of the Pulmonary Modulation Technology on which the Vortran Automatic Resuscitator Model RTM is based. Vortran Medical Technology has the exclusive right to manufacture and market the Vortran Automatic Resuscitator model RTM, based on a licensing agreement between Piper Medical and Vortran Medical Technology, for which Piper Medical receives periodic payment. The author reports no other conflicts of interest related to the content of this paper.

REFERENCES

1. Babic MD, Chatburn RL, Stoller JK. Laboratory evaluation of the Vortran automatic resuscitator model RTM. Respir Care 2007; 52(12):1718-1727.
2. Brower RG, Matthay MA, Morris A, Schoenfeld D, Thompson BT, Wheeler A. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. N Engl J Med 2000; 342(18):1301-1308.
3. Kallet RH, Jasmer RM, Pittet JF, Tang JF, Campbell AR, Dicker RA, et al. Clinical implementation of the ARDS Network protocol is associated with reduced hospital mortality compared with historical controls. Crit Care Med 2005;33(5):925-929.
4. Kallet RH, Campbell AR, Dicker RA, Katz JA, Mackersie RC. Effects of tidal volume on work of breathing during lung-protective ventilation in patients with acute lung injury and acute respiratory distress syndrome. Crit Care Med 2006;34(1):8-14.
5. Young MP, Manning HL, Wilson DL, Mette SA, Riker RR, Leiter JC, et al. Ventilation of patients with acute lung injury and acute respiratory distress syndrome: Has new evidence changed clinical practice? Crit Care Med 2004;32(6):1260-1265.
6. Wiedemann HP, Arroliga AC. Acute respiratory distress syndrome: Low-stretch ventilation improves survival. Cleveland Clin J Med 2000;67(6):435-440.

The authors respond:

We appreciate the opportunity to respond to Mr Piper's "clarification" of our study.[1] We are mindful that our paper and its abstract captured the attention of financial beneficiaries of the Vortran Automatic Resuscitator, and we commend Mr Piper for articulating his questions about the study in a scientific forum.

As we read Mr Piper's letter, he makes 3 contentions that he suggests "clarify" the findings in our paper.

First, he contends that the Vortran Automatic Resuscitator's variable tidal volume (V_T), which, as he states "automatically adjusts to decreasing compliance by increasing breathing rate and decreasing V_T, with relatively stable $\dot{V}_E$," is a benefit of its use

in patients with acute respiratory distress syndrome (ARDS). Implicit in his comment is that, in the context of the results of the ARDS Network trial,[2] which showed that a V_T of 6 mL/kg was associated with better survival in patients with ARDS, decreasing the V_T in response to decreasing compliance is beneficial and recommended. We believe that that contention, though broadly correct, overlooks the essential finding of the ARDS Network (in which our institution participated), that a specific V_T of 6 mL/kg is recommended, not a varying V_T, and not a V_T that exceeds 6 mL/kg, even if V_T decreases as the lung stiffens. Furthermore, in endorsing a maximum inspiratory pressure up to 50 cm H_2O, the "clarification" overlooks the target of a plateau pressure of < 30 cm H_2O in the ARDS Network trial,[2] which would probably be exceeded by a maximum inspiratory pressure of 50 cm H_2O in the absence of increased airway resistance (depending, of course, on the inspiratory flow rate). Furthermore, Mr Piper's comment about the device's automatic adjustment seems to imply that there is some intelligence in the adjustment process, which, of course, there is not. The adjustment is simply a mechanical response to a changing respiratory-system time constant. The only ventilators that make "intelligent" changes to the delivered V_T are much more sophisticated devices.[3]

The most important issue regarding "automatic" changes in ventilatory parameters is that, unlike any other ventilatory device, setting a "rate" on the Vortran device does not guarantee a preset number of *mandatory* breaths per minute, because the breaths are not time-triggered independent of the patient's respiratory-system mechanics (ie, resistance, compliance, and muscle activity). On the contrary, *spontaneous* breaths are pressure-triggered according to the interaction of the Vortran's internal leak flow (set by the "rate" knob) and the patient's inspired V_T and expiratory time constant. Indeed, the "rate" knob should be thought of not as a frequency control but rather as a trigger-sensitivity control. What the operator is really doing (with a passive patient) is setting the device to auto-trigger, much like a standard ventilator will do when there is a leak in the system.

The second contention is that our choosing a compliance of 14 mL/cm H_2O as a working condition in the study[1] was imprudent and cast the device's performance in an unfavorable light. As we stated, our goal was to examine the device's performance under 2 mass-casualty conditions that would simulate those in which a portable, inexpensive device might be considered desirable, such as poisoning causing neuromuscular paralysis (in which the lung compliance would be expected to be normal) and acute lung injury/ARDS (in which the lung compliance would be decreased). Still, patients with ARDS have been reported to have average compliances as low as 37 mL/cm H_2O, with a standard deviation of 23 mL/cm H_2O, so compliance values in the teens would be expected in perhaps 30% of patients.[4] In that context our choice of compliance values under which to simulate the use of the device seems defensible and appropriate.

Finally, Mr Piper found our statement about calculated P_{CO_2} misleading. We absolutely agree that only actual blood gas data from patients will settle the issue and allay concerns, but our experience in this study makes us reluctant to undertake actual clinical testing to resolve this.

Overall, we stand by our suggestions that, "The variable performance under changing load along with the lack of alarms should prompt caution in using the Vortran Automatic Resuscitator for emergency ventilatory support in situations where patients cannot be constantly monitored by trained and experienced operators."[1] As evidence that truth in science is replication of findings, we point out that conclusions from other groups echo our concerns about the device.[5]

Mark D Babic RRT
Respiratory Care Services
Fairview Hospital
Cleveland, Ohio

Robert L Chatburn RRT-NPS FAARC
James K Stoller MD MSc FAARC
Respiratory Institute
Cleveland Clinic
Cleveland, Ohio.

The authors report no conflicts of interest related to the content of this letter.

REFERENCES

1. Babic MD, Chatburn RL, Stoller JK. Laboratory evaluation of the Vortran Automatic Resuscitator model RTM. Respir Care 2007;52(12):1718-1727.
2. NHLBI Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute respiratory distress syndrome. N Engl J Med 2000;342(18):1301-1308.
3. Arnal JM, Wysocki M, Nafati C, Donati S, Granier I, Corno G, Durand-Gasselin J. Automatic selection of breathing pattern using adaptive support ventilation. Intensive Care Med 2008;34(1):75-81.
4. Mercat A, Richard JC, Vielle B, Jaber S, Osman D, Diehl JL, et al. Positive end-expiratory pressure setting in adults with acute lung injury and acute respiratory distress syndrome: a randomized controlled trial. JAMA 2008;299(6):646-655.
5. ECRI Institute. Vortran Automatic Resuscitator gas-powered resuscitators (also referred to as the Surevent) may spontaneously stop delivering breaths. Health Devices 2007;36(12):404-406.

More Environmental Prevention of Gram-Negative Infections Needed

I appreciated the excellent review article[1] by Robert Siegel on emerging antibiotic resistance of Gram-negative bacteria. Gram-negative bacteria account for a large percentage of the estimated 99,000 annual United States deaths due to hospital-acquired infections. Better antibiotic management and the development of new antibiotics are important for controlling Gram-negative bacteria. However, many environmental interventions exist that can prevent Gram-negative infections, but are often overlooked in hospital practice.

Hand-washing is the most important single step in preventing the spread of Gram-negative infections. Various studies have reported that viable bacteria are commonly found on the hands of health care providers; these include *Pseudomonas* (found on 1.3–25% of provider hands), *Acinetobacter* (3–15%), *Klebsiella* (17%), and vancomycin-resistant enterococcae (41%).[2] An intervention to increase the use of alcohol-based hand rub and gloves reduced Gram-negative infections by 60% and Gram-positive infections by 60% ($p < 0.001$ for each comparison) in a neonatal intensive care unit.[3]

An intervention that involved education of hospital cleaning staff was associated with a 64% reduction in vancomycin-resistant enterococcae infection (95% confidence interval 0.19–0.68).[4] Portable high-efficiency-particulate-air (HEPA) filters significantly reduce hospital airborne *Pseudomonas*.[5] Siegel[1] cited several sources that reported that better disinfection and man-