Letters

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Clarification of Performance Characteristics of the Vortran Automatic Resuscitator

In the December 2007 issue of RESPIRATORY CARE, the article by Mark Babic, Robert Chatburn, and James Stoller asks the worthwhile question of which particular ventilator models are suitable for disaster preparedness in regard to the context of managing large numbers of victims who may need mechanical ventilation.[1] The article focuses on the performance of one brand of device: the Vortran Automatic Resuscitator, which is a pressure-cycled automatic resuscitator. Although their study produced some interesting data, I believe that a different presentation of the information would be helpful in explaining and understanding the results reported by Babic et al.[1] All data included in the present letter were obtained from Table 2 in that report.

The points that need clarification include:

1. Changes in tidal volume (V_T) and respiratory rate associated with changes in lung compliance and airway resistance are a primary operating characteristic of all pressure-cycled ventilators, including the Vortran Automatic Resuscitator, and are normal and desirable.

2. The findings from Babic et al were dependent on the specific Vortran Automatic Resuscitator settings and pulmonary variables chosen for the study, which in some cases were inappropriate for the ventilation mode they used, and changes in device settings were needed.

3. Some meaningful trends in the data were not completely explained.

The Vortran Automatic Resuscitator, as described in the manufacturer's literature, is a pressure-cycled automatic resuscitator and thus is designed to deliver the same maximum inspiratory pressure (MIP) and positive end-expiration pressure (PEEP) under varying clinical conditions (Fig. 1). The report shows that at a nominal MIP setting at the lowest indicated range (20–30 cm H_2O), the Vortran Automatic Resuscitator automatically adjusts to decreasing compliance by increasing breathing rate and decreasing V_T, with relatively stable minute volume ($\dot{V}_E$). Important clinical research showed that a reduction in mortality of acute respiratory distress syndrome patients is associated with a reduced V_T.[2-6] Therefore, the device functioned exactly as intended and expected. However, it is undesirable to allow the V_T to drop close to the volume of the anatomical dead space, as was done in the study by Babic et al.[1] A clinician using any pressure-cycled, flow-controlled device should be prepared to increase the MIP setting upwards if the respiratory rate is above 20 breaths/min, as a way to ensure that the patient is receiving the appropriate V_T.

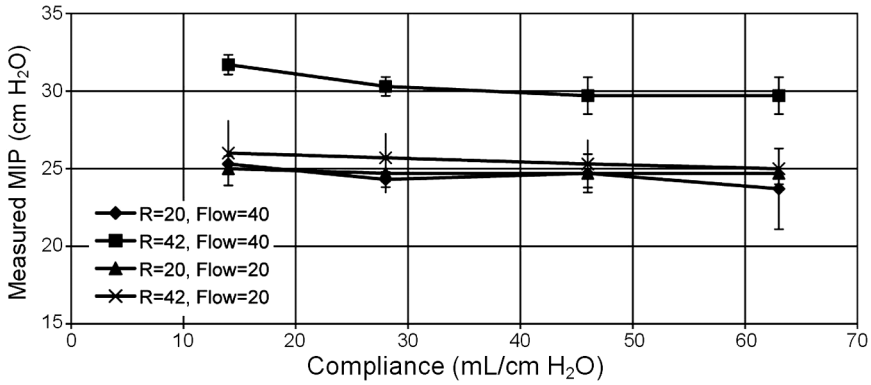

Fig. 1. Measured maximum inspiratory pressure (MIP) versus lung compliance for each of the 4 combinations of airway resistance (R) and set device flow with the Vortran Automatic Resuscitator. The error bars represent one standard deviation. All the measurements were done with the device set at the lowest indicated MIP of 20–30 cm H_2O. As expected, the figure shows that the device provided a MIP of 25 cm H_2O in a wide range of conditions, and that there was a MIP increase with a resistance of 42 cm H_2O/L/s and a set device flow of 40 L/min. (All data in this figure are from Table 2 in Reference 1.)

Issues discussed by Babic et al[1] concerning the appropriateness of the ventilation provided by the device were not the result of a defect of the device (which might be inferred by some readers) but were more a question of the ventilation mode chosen, the device settings (MIP of only 20–30 cm H_2O), and the pulmonary variables chosen for the experiment (compliances of 14–63 mL/cm H_2O, resistances of 20 and 42 cm H_2O/L/s). Figures 1 and 2 show the measured MIP values and the calculated alveolar $\dot{V}_E$ values, respectively. Although the Vortran Automatic Resuscitator is relatively stable over most compliance settings, the very low compliance of 14 mL/cm H_2O with the MIP setting of only 20–30 cm H_2O yields a poor level of alveolar ventilation, associated with a highly elevated respiratory rate ($>$ 40 breaths/min).[1] In such a situation a trained clinician observing a respiratory rate $>$ 20 breaths/min can increase the MIP setting up to 50 cm H_2O, which would increase MIP and PEEP to compensate for this serious lung condition. If necessary, an auxiliary PEEP controller may be useful in the most serious cases.

Although no measurements were made of alveolar $\dot{V}_E$ or P_{aCO_2}, the report[1] estimated expected values under the assumed clinical conditions (Fig. 3). Alveolar $\dot{V}_E$ and P_{aCO_2} are important because they represent the quality of ventilation provided to the patient, along with total $\dot{V}_E$, V_T, and MIP. As expected and shown in Figures 2 and 3, alveolar $\dot{V}_E$ drops off and P_{aCO_2} increases with decreases in lung compliance and a constant nominal MIP setting of 20–30 cm H_2O. That result is expected as a result of the decreasing V_T and the increasing respiratory rate, and may be corrected simply by adjusting the MIP upward to maintain a clinically appropriate V_T and respiratory rate. The statement by Babic et al that the "calculated P_{aCO_2} was never in the normal range" is misleading because the values ranged from low to high for the chosen settings in the study, and values in the normal range could be achieved by adjusting the Vortran Automatic Resuscitator's operating conditions.

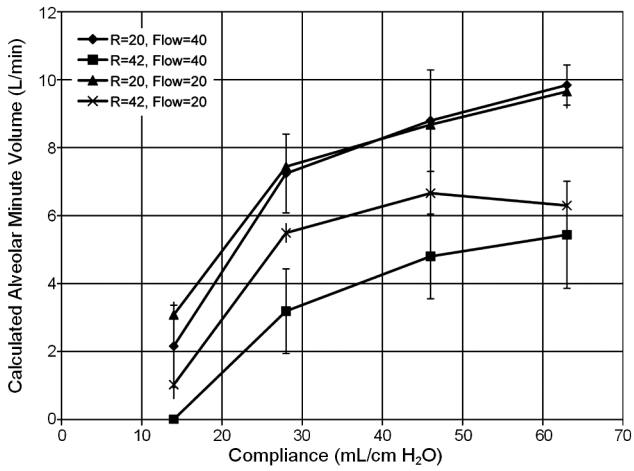

Fig. 2. Calculated alveolar minute volume versus lung compliance for each of the 4 combinations of airway resistance (R) and set device flow with the Vortran Automatic Resuscitator. The error bars represent one standard deviation. All the measurements were done with the device set at the lowest indicated 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.)

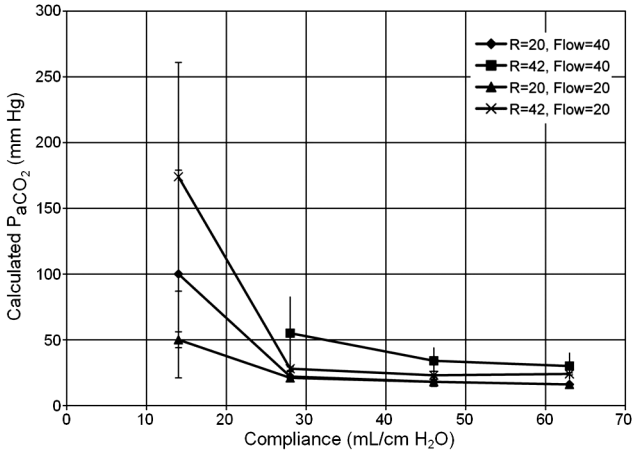

Fig. 3. Calculated P_{aCO_2} versus lung compliance for each of the 4 combinations of airway resistance and set device flow with the Vortran Automatic Resuscitator. The error bars represent one standard deviation.[1] All the measurements were made with the device set at the lowest indicated maximum inspiratory 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.

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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