TITLE: ANESTHESIA VENTILATOR PERFORMANCE, DELIVERED TIDAL VOLUME, AND PEEP
AUTHORS: P.H. Pan, MD, and J.J. van der Aa, PhD
AFFILIATION: Dept. of Anesth., Univ. of Fla. College of Med., Gainesville, FL 32610-0254

We evaluated how positive end-expiratory pressure (PEEP) affects ventilator output (VO) and delivered tidal volume (V_Td) in 3 anesthesia machine ventilators.

The Narkomed III and Ohmeda Modulus II with 7000 or 7810 ventilator were tested with a standard, polyethylene-corrugated-tubing circle anesthesia breathing circuit at a fresh gas flow of 0, inspiratory-to-expiratory ratio of 1:2, and respiratory rate of 10 breaths/min. Calibrated V_Td was 500 or 1000 ml; a test lung simulated compliance (C) of 0.15, 0.1, 0.05, 0.03, 0.02, and 0.01 L/cm H_2O and resistance (R) of 2 and 20 cm H_2O s/L. PEEP was increased in 5-cm H_2O steps from 0 to 30 cm H_2O. Gas flow was measured at the output of the ventilator bellows and at the Y piece with a differential pressure transducer; VO was measured by flow signal integration. Measurements were repeated 5 times; data from the 3 machines were compared by ANOVA and Tukey.

When PEEP increased, VO and V_Td of all 3 machines decreased ($P < 0.05$), especially at low V_T and low C (fig.). Decreases in VO and V_Td with the Narkomed were less than with the 7000 and 7810 ($P < 0.05$). V_Td decreases were due to volume decreases from both VO and breathing circuit. Volume decreases from breathing circuit, which were calculated as VO - V_Td, did not differ among the 3 machines; thus the difference in V_Td between Narkomed and Ohmeda machines was due mainly to the different VO. Change in R did not alter V_Td or VO.

Ventilator design may improve VO and add feedback circuitry to adjust for volume losses. V_Td must be monitored to detect hypoventilation, especially during PEEP.

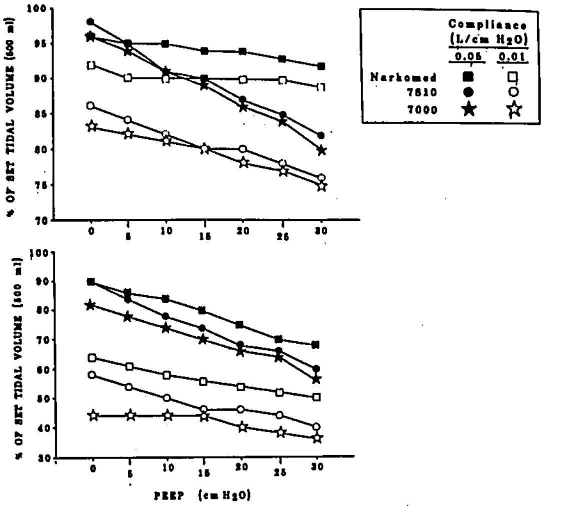

FIG. Effect of increasing PEEP on mean VO (top) and mean V_Td (bottom) with 3 anesthesia ventilators. Abbreviations are defined in the text.

A421

TITLE: CONTINUOUS CARDIAC OUTPUT MEASUREMENT IN ICU PATIENTS
AUTHORS: M.L. Yelderman, M.D., M.A. Ramsay, M.D., M.D. Quinn, Ph.D., A.W. Paulsen, Ph.D., R.C. McKown, Ph.D.
AFFILIATION: InterFlo Medical, Plano, TX 75074
Baylor Medical Center, Dallas, TX 75246

A new heat thermodilution method has been developed to measure cardiac output automatically and continuously[1] and has been evaluated in sheep[2]. Pulmonary artery catheters are modified to locate a 10 cm long heating element in the right ventricle during use. An average of 7.5 watts of heat is added to the blood according to a pseudo random binary sequence. The resulting temperature change is detected downstream in the pulmonary artery and cross-correlated with the input sequence to produce a thermodilution "washout" curve. Cardiac output is computed from a conservation of heat equation using the area under this curve.

After obtaining institutional approval and informed consent, flow-directed pulmonary artery catheters with heating elements were inserted into five ICU patients (75 - 110 kg). The catheter was connected to the new device and cardiac output measured continuously. At convenient times, the catheter was connected to a Marquette monitor and two to five room temperature 10 cc bolus thermodilution cardiac output determinations made asynchronously with ventilation. For comparison, an average of the heat thermodilution(HTD) method before and after the sequence of bolus injections was compared to the average of the complete set of bolus thermodilution(BTD) determinations. The relative error (100*(BTD-HTD)/BTD) was computed.

The time plot of one patient is shown in the figure. Twenty-eight data pairs were obtained, flows ranging from 2.5 to 10.0 L/min. The regression coefficient (R) is 0.94. The mean relative error is -5% and the standard deviation of the relative error is 12%.

Despite the limitations of bolus thermodilution cardiac output as a "gold" standard, the new heat thermodilution method is demonstrated to be effective in measuring cardiac output continuously in intensive care patients. The technique requires no user calibration and eliminates the need for bolus thermodilution.

References:
1. Yelderman ML. Continuous measurement of cardiac output using stochastic system identification techniques. J Clin Monit(In Press)
2. Yelderman ML, Quinn MD, McKown RC. Continuous thermodilution cardiac output in sheep. Soc CV Anes Meet, 1990.