

Title : INSPIRATORY WORK DURING CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP) VENTILATION WITH NEW GENERATION VENTILATORS.

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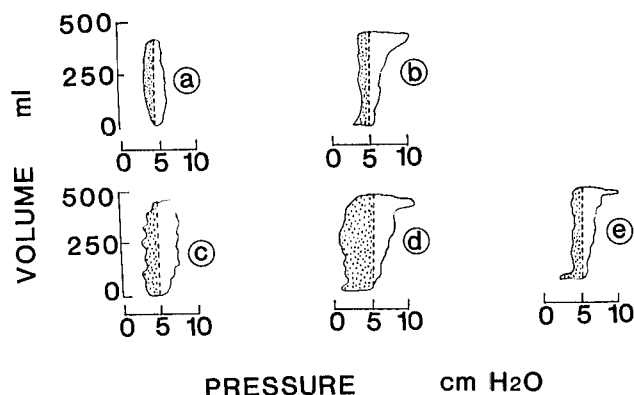
Introduction. CPAP ventilation can be provided by continuous flow (CF) or demand valve (DV) systems. DV systems incorporated into ventilators, which are more economical than CF systems with fresh gas, are sometimes poorly tolerated by patients. This has been attributed to an excessive inspiratory effort required to open the demand valve, and to insufficient gas flow delivered during inspiration. Indeed, several studies have shown the work of breathing to be increased more with conventional DV systems than with CF systems. In the new generation ventilators the delay time of valve opening is shortened, and the flow delivered upon detection of the patient's inspiratory effort is closely adjusted to satisfy inspiratory requirements. This study was designed to measure the inspiratory work in patients undergoing CPAP ventilation with 3 of these new devices, and with a CF system.

Methods. With institutional approval and informed consent, 8 intubated patients (age : 40 to 58 Yr) were enrolled in this study. CPAP ventilation was being used in the weaning process after acute respiratory failure following major surgery (4 cases) or multiple trauma (4 cases). At the time of the study, all patients had normal cardiovascular function and blood gases with an FiO_2 of 0.4 or less. They were studied in the semi-recumbent posture.

On the same day, the 4 CPAP systems were studied for each patient in a random order, at the same level of positive end expiratory pressure (PEEP), after constant respiratory rate (RR) and tidal volume (TV) were achieved. The CF system was a continuous high-flow device (50 l/min) with a 6 l bag (compliance 60 ml/cmH₂O) inserted between a humidifier and the patient's tracheal tube. PEEP was provided with an "Ambu" PEEP valve. The DV systems were those of 3 recently marked ventilators : Dräger E-VAR, Puritan Bennett 7200R, and Hamilton VeolarR. For the Dräger E-VAR and the Puritan Bennett 7200R, the pressure used to regulate inspiratory flow from the beginning of the patient's inspiratory effort is taken in the expiratory tube of the ventilator. For the Hamilton VeolarR, this pressure was taken into the ventilator, in the inspiratory tube above the humidifier ("Veolar Int."), and at the patient's mouthpiece level ("Veolar Y").

For each CPAP trial, pressure at the airway opening (Pao), esophageal pressure (Pes) and airflow (V) were simultaneously measured using Statham P50R transducers and a Gould pneumotachygraph. The tape recordings of these signals were digitized and analyzed using a microcomputer method previously described¹. From the generated Pao-volume curves, we measured the inspiratory work required to overcome the impedance of the CPAP system (Wadd). From the transpulmonary pressure-volume curves, we measured inspiratory elastic (Wel) and resistive (Wres) works². Total inspiratory work (Wtot.) was defined as Wadd + Wel + Wres. Calculated works were expressed as millijoules (mJ) per liter of TV. Each patient had 25 cycles analyzed for each CPAP system.

Results. The figure shows an example of typical Pao-volume loops in one patient.



- (a) CF system, (b) Puritan Bennett 7200R,
(c) Dräger E-VAR, (d) Hamilton VeolarR "Int",
(e) Hamilton VeolarR "Y". The stippled area represents Wadd.

The table shows the main results (means \pm SE).

	CF System	Puritan Bennett 7200 R	Dräger E-VA	Hamilton Veolar R "Int"	Hamilton Veolar R "Y"
TV	401 \pm 27	389 \pm 25	368 \pm 30	433 \pm 37	439 \pm 39
RR	21.5 \pm 1.5	20.8 \pm 1.5	20.5 \pm 1.5	21.4 \pm 1.4	20.7 \pm 1.6
PEEP	6.5 \pm .5	6.4 \pm .4	6.5 \pm .5	6.2 \pm .3	6.5 \pm .4
Wadd	133 \pm 15	80 \pm 16	150 \pm 20	257 \pm 40*	78 \pm 30*
Wel	503 \pm 30	429 \pm 32	512 \pm 47	561 \pm 26	540 \pm 18
Wres	118 \pm 33	223 \pm 40*	184 \pm 40*	187 \pm 39*	221 \pm 51*
Wtot	754 \pm 70	722 \pm 71	846 \pm 140	1005 \pm 77*	839 \pm 68

* $p < .05$ compared with the CF system value

+ $p < .05$ Hamilton VeolarR "Int" vs "Y"

Discussion. Compared to a CF system, Wres with these DV systems is only slightly higher, and Wadd is similar provided that the pressure used to regulate inspiratory flow is taken on the expiratory tube or at the patient's mouthpiece level. This indicates a satisfactory adjustment to the patient's inspiratory requirements. The same values of Wel found with all CPAP systems are consistent with unchanged RR, TV, PEEP (and thus FRC) from one system to another. Finally, except for the Hamilton VeolarR "Int", Wtot is not more elevated with these DV systems than with a CF system, which is consistent with their usually good clinical tolerance.

References.

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