MINI REVIEW

During conventional ventilation of preterm infants, dead space washout by deliberate leakage flow was studied experimentally

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ABSTRACT

A significant risk factor for the development of chronic lung disease in preterm newborns is invasive mechanical ventilation. Reduced ventilation effort and a decreased risk of ventilator-induced lung damage would result from a reduction in the dead space as a percentage of the total breathing volume. We compared the effectiveness of mechanical dead space washout via uncontrolled and controlled leakage flow in this experimental study to remove CO_2 during conventional breathing in preterm newborns.

Key Words: *Bronchoscopy, pleural disease, interventional pulmonology*

INTRODUCTION

Heart valve Each of the three regularly used neonatal ventilators was linked to a test lung and was running on the usual conventional ventilating parameters. The test lung was continually filled with CO_2 to keep the physiological end-expiratory pCO_2 level constant throughout ventilation. A side port at the junction between the endotracheal tube and the flow sensor allowed breathing gas to escape passively or, in a different experimental arrangement, under the control of a pump. In both trials, end-expiratory CO_2 measurements were made and contrasted with end-expiratory CO_2 levels of ventilation without active dead space leakage. A substantial decrease in end-expiratory pCO_2 was achieved after dead space washout. The mean reduction was 14.1% under uncontrolled leakage conditions and 16.1% under regulated leakage circumstances a more stable ventilation by preventing uncontrolled loss of tidal volume during inspiration. Reduced end-expiratory pCO_2 can be achieved by washing out dead space using leaky flow. Comparable outcomes are produced by both controlled and uncontrolled leakage, however careful regulation of leakage enables more stable ventilation by preventing uncontrolled loss of tidal volume during inspiration[1,2].

The influence of dead space on breathing effort in preterm newborns is significant1. The need for high tidal volume ventilation in severely preterm infants increases with decreasing body mass. High tidal volumes are required to overcome the mechanical dead space. This is caused by the respirator's relative dead space expansion. In cases with a large dead space, high inspiratory flow and long pressure plateaus are required for adequate CO_2 elimination [3, 4]. In addition to high tidal volumes, these two factors also promote ventilator-induced lung injury and bronchopulmonary dysplasia [5, 6]. Therefore, reducing dead space may help improve pulmonary outflow. Proximal flow measurement devices are placed between the Y-piece connector and the endotracheal tube on all ventilators for very small preterm infants. These sensors not only increase mechanical dead space but also increase alveolar CO_2 by encouraging the absorption of expired gas. Additional installations, such as end-expiratory CO_2-sensors or closed suctioning devices, further increase mechanical dead space. Technically speaking, clinical procedure cannot currently utilise dead-space-free ventilation. Commercial dead space washout methods are unavailable, and because they interfere with flow metering and air conditioning, it is challenging to reduce dead space by washout

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methods in routine care. This study set out to compare controlled and uncontrolled leakage flow methods for dead space washout in order to assess their efficacy. In which the authors report a continual uncontrolled gas leakage from the endotracheal tube adapter of roughly 0.35 L/min during ventilation of preterm newborns with a mean body weight of 856 g, had an impact on the experimental design of our work. In our investigation, three different ventilators—the Babylog 8000 plus (Dräger Medical) (Dräger), Fabian +nCPAP evolution respirator (Acutronic Medical Systems AG), and AVEA® standard ventilator—were investigated in conjunction with a test lung (Dräger Medical) modelling the lung of a 1500 g preterm newborn (Vyaire Medical). The standard ventilation settings were identical across all ventilators. To maintain a consistent physiological end-expiratory pCO_2 level during breathing, 88 ml/min of CO_2 were constantly flowed into the test lung. makes the experimental setup visible. Under two different circumstances, leakage flow for dead space washout was carried out. A rupture in the endotracheal tube connector and a thin leakage tube were used to create an uncontrolled leakage flow in the first experimental setting. Given that a tube's flow resistance is dependent on both its diameter and length, the leaky tube might be reduced to achieve an average leakage flow of 0.35 L/min. With a shorter leakage tube linked to the endotracheal tube connector perforation, an SP 100 EC pump (Schwarz Precision GmbH + Co. KG) provided a controlled leakage flow of 0.342 L/min to test the effects. The fixed pump capacity (0.4 L/min) and the leakage tubes' flow resistance led to this controlled leakage flow. A red-y small metre GSM (Vögtlin Instruments GmbH) was used to measure both controlled and uncontrolled leakage flow. The chosen leakage fluxes washout roughly 0.5 ml of dead space in 0.1 seconds [7-8]. Therefore, even at high ventilation frequency, a large CO_2 washout should be possible. The leakage flow continuously dilutes breathing gas in the region between the Y-piece and the leakage aperture, or in the vicinity of the flow sensor. Therefore, a measurement of end-expiratory pCO_2 in this region would be inaccurate. Due to this, pCO_2 monitoring was additionally set up in the space between the leakage aperture and the study's "patient." End-expiratory pCO_2 measurements were made with and without leakage, as well as with controlled and uncontrolled leakage. The end-expiratory pCO_2 was assessed 1 minute after each change in leakage to show that the situation was stable. Each ventilator model was subjected to twenty measurements for each experimental condition. MedCalc® version 18.11.3 was used to conduct one- and two-way analyses of variance on the measurements. The Student-Newman-Keuls test was used to do pairwise posthoc analysis in the one-way analysis of variance.An ethical evaluation was not necessary because the tests did not include human or animal subjects. There are several options for active dead space washout that have been described in the literature. One of these options is active washout with pump-injected flow, which has the advantage of completely washing out dead space. However, this technique necessitates special tubing and runs the risk of causing an uncontrolled overextension of the lung in the event of tubal occlusion. The split flow technique, which was first described by our own research team, mostly washes out the dead space between the flow sensor and the connector for the endotracheal tube or the associated closed suctioning device, but not the dead space of the endotracheal tube. The benefit of not needing a pump is provided, however additional big diameter split flow tubes are needed. Due to the similar location of the perforation in the endotracheal tube connector, method (3), dead space washout with uncontrolled leakage flow, which has equal efficacy to the split flow technique, has the drawback of lessening ventilation. Less inspiratory volume reaches the lungs as a result of the pressure-induced increase in leakage flow during inspiration. The leakage flow then decreases in line with expiration. This lessens the efficiency of the dead space washout and explains why controlled leakage is somewhat more effective than uncontrolled leakage, as stated in this work. Further analyses would be required to identify the effects of leakage settings other than those employed in Claure et alstudy8, .'s which served as the basis for the choice of controlled and uncontrolled leakage flows.Even though there are numerous solutions available, mechanical dead space washout has not yet become widely used. This can be attributable to the procedure's two primary issues: the requirement for breathing gas conditioning and its potential detrimental effect on precise flow measurements. Expiratory tidal volume is utilised in flow measurement in neonatology to determine delivered tidal volume. The expiratory flow increases with each incremental washout flow whereas it decreases with leakage. The consequence is either a greatly overestimated or underestimated expiratory tidal volume. A flow sensor can theoretically be calibrated to a washout flow. For this to be possible, the washout flow should essentially remain constant; however, in the absence of a pump, such flows significantly fluctuate throughout the breathing cycle in reaction to pressure changes. When a leakage flow is controlled through a pump, it never varies, even when the pressure changes during inspiration and expiration. The constant control makes it feasible to calculate the tidal volume precisely. A zero value shift results from the necessary calibration to a constant washout flow. As a result, the accuracy of the tidal volume measurement is unaffected. Thus, the effect of the leakages, which are common in neonatology, on the tidal volume measurement is unaffected.

The sort of test lung that was accessible for this investigation was one of its limitations; as a result, settings that would be appropriate for a 1500 g youngster were selected. The patients in the Claure et al. study8 had an average weight below 1000 g, in contrast. The technical dead space that can be washed out is independent of patient weight simply in terms of tidal volume. By dramatically lowering end-expiratory pCO_2 levels, washout by leaky flow can mitigate the negative effects brought on by mechanical dead space. The uncontrolled loss of tidal volume that happens during inspiration when leakage is not regulated makes controlled leakage not only as effective as uncontrolled leakage flow, but it also enables a more steady ventilation. Because this in vitro study's results cannot be used to determine its therapeutic significance, more clinical research is necessary. The use of leakage flow, however, eliminates the need for breathing gas conditioning and allows for the maintenance of these equal conditions without heating the breathing hose. Contrarily, a leakage flow has no impact on the humidity or temperature of the respiratory gas entering the patient's lungs. Thus, the use of the leakage flow reduces the requirement for the treatment of breathing gases. End-expiratory pCO_2 without leakage with the Fabian ventilator during conventional breathing was 38.3 mmHg, 95% CI (37.7, 38.8). End-expiratory CO_2 was 32.8 mmHg, 95% CI (32.2, 33.3) with uncontrolled leakage, and 32.2 mmHg, 95% CI (32.2, 32.3) with regulated leakage (31.6, 32.7). With uncontrolled leakage, dead space washout reduced pCO_2 by 14.4%, whereas with regulated leakage, it decreased by 15.9%. Although it requires more big diameter split flow tubes, it has the benefit of not requiring a pump. Due to the same location of the perforation in the endotracheal tube connector, the third method of dead space washout with uncontrolled leakage flow has comparable efficacy to the split flow technique.Uncontrolled inspiratory leakage significantly reduces ventilation, which is a significant drawback. Less inspiratory volume reaches the lungs during inspiration because pressure causes the leakage flow to rise. The leakage flow then decreases proportionally during expiration. This lessens the efficiency of the dead space washout and explains why controlled leakage is somewhat more effective than uncontrolled leakage, as stated in this work. Further analyses would be required to identify the effects of leakage settings other than those employed in Claure et al study, .'s which served as the basis for the choice of controlled and uncontrolled leakage flows. Expiratory tidal volume is utilised in flow measurement in neonatology to determine delivered tidal volume. The expiratory flow increases with each incremental washout flow whereas it decreases with leakage. The consequence is either a greatly overestimated or underestimated expiratory tidal volume. A flow sensor can theoretically be calibrated to a washout flow. For this to be possible, the washout flow should essentially remain constant; however, in the absence of a pump, such flows significantly fluctuate throughout the breathing cycle in reaction to pressure changes. When a leakage flow is controlled through a pump, it never varies, even when the pressure changes during inspiration and expiration.

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