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Is the Pressure Control Mode for Pediatric Anesthesia Machines Really Required?

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Dear Editor,

Choosing an appropriate anesthesia machine for mechanical ventilation of pediatric patients is of paramount importance because small changes in the fractions of the delivered tidal volume can cause a significant difference from the desired tidal volume.

The anesthesia machines have classically been divided up into pressure or volume controlled modes, with two main characteristics; the limit (what determines the size of the breath), and the cycle (what actually ends the breath). The traditional anesthesia machines with volume controlled mode are not able to deliver precisely small tidal volumes to the pediatric patients. In the traditional anesthesia machines, fresh gas directly streams to the breathing circuit, so if 6 L/min of fresh gas is added to the previous setting (6 liters/60 seconds) 100 mL/s will be added to the delivered tidal volume, and if the inspiratory time is 2 seconds, 200 mL will be added to the tidal volume. These differences significantly increase the desired tidal volume. Therefore, the conventional anesthesia machines with the volume-controlled ventilation mode are not suitable to deliver a tidal volume less than 200 mL. During ventilation of neonates or children (in which tidal volume is less than 200 cc, respiratory rate is at least 16 - 20/minute and with a 1:2 I/E ratio, inspiratory time is less than 1 second), these differences are not acceptable. Thus, anesthesiologists usually use pressure-controlled ventilation rather than volume-controlled ventilation for pediatric anesthesia.

A pressure-limited, time-cycled pulmonary ventilator includes a pressurized gas system that supplies respiratory gas to a patient at a selected inspiratory flow rate; an exhalation valve that opens an expiratory flow path in response to the elapsing of a selected inspiratory time period, and maintains a selected proximal pressure limit during the inspiratory time period.

The tidal volume that results from a pressure-targeted machine is attributable to the set inspiratory pressure and patient's lung-thorax compliance. Circuit compliance, fresh gas flow changes, and even small leaks around an uncuffed endotracheal tube do not modify the delivered tidal volume (1). Pressure-controlled ventilation offers the advantage of limiting barotrauma in the condition of changing lung compliance, but a decrease in tidal volume will occur in the pressure-controlled ventilation mode, when the compliance of the lung is decreased or a pressure against the abdomen is created (e.g. in laparoscopic surgeries) (2).

There are also some pediatric ventilators that deliver the breath by setting the inspiratory and expiratory duration and setting the flow of gas, but management of patients with these ventilators can lead to hypoventilation in the circumstance of increasing of the pulmonary resistance or reversal of muscle relaxants.

To deliver a precise tidal volume, some new anesthesia machines have equipped with fresh gas decoupling valves. In these machines, the fresh gas (FGF) is not delivered to the inspiratory limb during inspiration. Practically, it means that FGF does not increase the tidal volume. The function of the fresh gas decoupling valve is to provide a precise delivery of the set tidal volume unaffected by varying fresh gas flow rates. During the inspiratory phase of ventilation, the valve closes, allowing only gas from the ventilator piston chamber to be delivered through the inspiratory branch to the patient. During the expiratory phase, the valve opens, allowing the ventilator piston chamber to fill with a mixture of the exhaled gas that has passed through the absorber and fresh gas (3).

A second method for accurate delivery of desired tidal volume is compliance compensation, to replace volume lost to the breathing tubes. A potentially large percentage of the bellows volume is lost into the breathing circuit, secondary to compliance and compression. Leaks and sampled gas flow will further reduce desired tidal volume (4). To ensure that the set tidal volume will be delivered to the patients, new anesthesia machines involve a preuse leak and compliance test during which the end of the circuit must be occluded. The total compliance will be measured and the machine use this data to adjust piston or bellows movement, according to desired pressure airway setting (5).

The anesthesiologist can use volume-controlled ventilation by a modern anesthesia machine that equipped with fresh gas decoupling valves and compliance and fresh gas compensation technology with confidence. Minimal tidal volume as low as 30 mL can be delivered precisely (5). The anesthesiologist should not persist in ordering a ventilator with multiple ventilation modes. Rather, choosing a ventilator with a unique mode that delivers a precise tidal volume would be suitable.

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