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DO ANAESTHESIA VENTILATORS DELIVER WHAT THEY SHOULD – A COMPARATIVE EVALUATION IN THE NEONATAL LUNG MODEL

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Introduction:

Intraoperative ventilation of small children demands high standards for the technical performance of anaesthesia ventilators in terms of precision, comfort and safety [1]. The present work evaluates the performance of four modern anaesthesia ventilators regarding precision of ventilation, effectiveness of pressure support and time required to change oxygen concentration in the lungs. We hypothesized that the effectiveness of ventilation differs depending on the system and ventilator technology.

Methods:

Our neonatal lung model was characterised by a compliance of 5 ml/cmH2O and FRC of 90 ml. The ventilators included were Atlan (piston), Perseus (turbine; both Dräger Medical, Germany), Carestation 650 (bellow; GE, USA) and Flow-C (volume reflector; Getinge, Sweden). Volume-controlled ventilation (VCV) and pressure-controlled ventilation (PCV) targeted a tidal volume (TV) of 20 ml, a breathing rate of 35/min and PEEP 5 cmH2O under BTPS. Precision of ventilation was determined by means of delivered TV without and with leakage (_L). Pressure support ventilation (PSV) was evaluated regarding trigger response rate, trigger delay (TD) and pressure time product (PTP) until PEEP was reached. Time of change in oxygen concentration was assessed by means of an increase from 21% to 90% oxygen concentration (T90) in the FRC, at 1 and 10 L/min fresh gas flow during PCV.

Results:

Compared to the set value, mean TV was 12% and 14% higher in the Atlan and Carestation 650, but 13% and 8% lower in the Flow-C and Perseus during VCV. Compared to TV, TV_L was 7±0.8% lower during VCV but only 2±0.3% lower during PCV in all devices. During PSV all breaths were captured in the Carestation 650 and Flow-C, but only 93±2% in the Atlan and 92±8% in the Perseus, regardless of the leakage. TD ranged from 171±2 ms (Flow-C) to 235±0 ms (Perseus; Atlan: 176±2 ms; Carestation: 184±1 ms). PTP was lowest in the Atlan (57±5 cmH2O*s) and highest in the Perseus (116±4 cmH2O*s; Flow-C: 71±1 cmH2O*s; Carestation: 89±3 cmH2O*s). At 1 L/min fresh gas flow T90 was 101±2 s in the Carestation 650, 107±1 s in the Flow-C, 220±16 s in the Atlan and 569±26 s in the Perseus. Increasing fresh gas flow decreased T90 by 35%, 7%, 27% and 88%, respectively.

Discussion:

Precision of ventilation differs considerably between modern anaesthesia machines. The piston and the bellow ventilator overdelivered on tidal volume whereas the flow accelerating ventilators underperformed. When a leakage is present, PCV is more effective regardless of the system in use. During assisted breathing, the turbine driven Perseus performed worst, compared to less distinct differences between the other systems. Times required to change gas concentration at low flow varied vastly. The inconsistent effect of increased fresh gas flow highlights the impact of the technology used.

Reference:

[1] Spaeth J, Schumann S, Humphreys S. Understanding pediatric ventilation in the operative setting. Part I: Physical principles of monitoring in the modern anesthesia workstation. Paediatr Anaesth 2022;32(2):237-246.