SHORT REPORT

Respiratory function monitoring during neonatal emergency transport

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This study reports for the first time the use of a respiratory function monitor in a prospective observational cohort of ventilated babies during transport. All 17 babies achieved target transcutaneous carbon dioxide tension within 15 minutes. Fifteen babies had improved ventilation with changes guided by the respiratory function monitor. The monitor was easy to use and useful.

In line respiratory monitoring of ventilated neonates is often used in the neonatal intensive care unit.^{1,2} Various monitors have been used to guide the clinical management of the ventilated neonate displaying flow waveforms, tidal volumes, leak around the endotracheal tube, and inflating pressures.³ Monitoring with a pulse oximeter and electrocardiograph leads is standard during transport.⁴ More recently, non-invasive monitoring of end tidal CO₂ and transcutaneous CO₂ and O₂ tension has been used.

The purpose of this study was to investigate the ease of use of a respiratory function monitor (RFM) during neonatal emergency transport to improve ventilation. The primary outcome was to determine how often transcutaneous CO₂ tension (TcPco₂) readings in the range 4.7–7.3 kPa were achieved within 15 minutes of initiation of mechanical ventilation. The secondary aim was to investigate how the data from the monitor influenced decisions on ventilation.

METHODS

The RFM used was the Florian Infant Graphic Monitor (Acutronic Medical Systems AG, Zug, Switzerland). It is a portable, stand alone monitor; it weighs 3.1 kg and measures 25 × 15 × 15 cm. It was chosen because we routinely use it and are therefore more familiar with its use than other models. It measures and displays flow volume and pressure curves, flow-pressure-volume loops, airway pressures, expired tidal volume, endotracheal tube leak, peak inflating pressure, positive end expiratory pressure, respiratory rate, and minute volume on intubated patients. A reusable hot wire flow sensor is positioned between the ventilator circuit Wye piece and the endotracheal tube connector. It has a 1 ml dead space and is accurate during neonatal ventilation to ± 8%. The TcPco₂ monitor used was the Microgas 7650 system with Combi.M sensor 82 (Linde, Switzerland) applied to the skin of the anterior chest or abdomen.

The RFM was used during stabilisation and transport of neonates by the Newborn Emergency Transport Service (NETS) in Victoria, Australia. NETS is a state wide service responsible for the transport of more than 600 ventilated babies a year. The RFM was taken with the transport equipment when an infant required, or was likely to require, ventilation, one of three neonatal transport fellows was available, and the transfer was by road. Air transports were excluded because of lack of certification. The RFM was

mounted in a metal bracket on the transport cot, or carried separately. Neonatal fellows were given specific training in the use of the RFM and interpretation of graphical and numerical output and were accompanied by a trained transport nurse. The TcPco₂ monitor was applied at least 15 minutes before the start of assisted ventilation and respiratory function monitoring by the transport team and calibrated from an arterial blood gas. An initial expired tidal volume of 5 ml/kg and a minute volume of 250–350 ml/kg were used to determine initial ventilator settings. Further adjustments of inspiratory time, expiratory time, ventilator rate, and the endotracheal tube size/position were made on the basis of the RFM data and transcutaneous blood gases. TcPco₂, ventilator settings, tidal volume, and minute volume were recorded at five minute intervals for the first 15 minutes, and thereafter at 15 minute intervals during transport. Changes to ventilation using RFM data and arterial blood gas results were recorded.

RESULTS

Seventeen babies were enrolled with a mean gestation of 30 weeks (range 24–40). Duration of ventilation was 15–120 minutes (median 60 minutes). Twelve babies were ventilated for respiratory distress syndrome and one each for pneumonia, chronic lung disease, septicaemia, hypoxic ischaemic encephalopathy, and gastroschisis with pneumonia.

Within 15 minutes of the start of assisted ventilation, 16 babies (94%) had a TcPco₂ in the range 4.7–7.3 kPa, and eight (47%) had a tidal volume and minute volume within the target range. Changes were made to ventilation variables in 15 babies (94%) on the basis of information from the RFM during transport, all resulting in improved ventilation. Table 1 summarises problems identified by the RFM. Seven babies had high TcPco₂ after 15 minutes, which resolved with interventions directed by RFM readings. One baby had abnormal RFM data resulting in rapid correction of a major ventilator circuit leak before clinical compromise.

DISCUSSION

In this study, setting the initial ventilator variables by measuring tidal volume and minute volume was associated with TcPco₂ values in the normal range for all babies by 15 minutes after the onset of ventilation by the NETS team. We recognise that the study design and numbers do not allow this result to be attributed directly to the use of the RFM to target tidal volumes and minute volumes. However, after the initial ventilator set up, the maintenance of normal ventilation was helped by targeted intervention based on RFM data.

Inclusion of the monitor on the transport cot was acceptable to the team and did not interfere with the transport of the baby. Limitations of the monitor are currently the size, weight, and need for a 240 V power source.

Table 1 Problems identified with the respiratory monitor

Problem	Number of occurrences	Action	Result
Air trapping	4	(1) Decreased rate and PIP (2) Decreased rate and PEEP (3) Decreased rate and Ti (4) Decreased rate, Ti, and PIP	Stopped gas trapping Stopped gas trapping, reduced FiO_2 Improved TcPCO_2 Improved gas trapping, normalised TcPCO_2
ETT leak	4	(1) Ventilator circuit changed (2) ETT position changed (3) ETT leak accepted (4) ETT Leak accepted	Leak ablated Leak ablated No change No change
Asynchronous interaction between the baby and the ventilator	3	(1) Noted (2) Rate increased (3) Morphine given	Improved with increased V_t , TcPCO_2 improved Synchrony Synchrony, TcPCO_2 normalised
Inappropriately low expired V_t	5	(1) PIP increased (2) PIP increased (3) Air trapping reduced (4) Leak ablated	TcPCO_2 normalised TcPCO_2 improved Improved V_t and TcPCO_2 Improved V_t
Inappropriately high expired V_t	3	(5) PIP increased, synchrony improved (1) PIP reduced (2) PIP and Ti reduced (3) PIP and Ti reduced	V_t improved V_t reduced V_t reduced V_t reduced
Low MV	1	ETT position	MV normalised
High MV	1	Rate reduced	Arrived at destination before result
Long Ti	1	Ti reduced	
Short Ti	1	Ti increased	

PIP, Peak inspiratory pressure; PEEP, peak end expiratory pressure; FiO_2 , fractional inspired oxygen; Ti, inspiratory time; TcPCO_2 , transcutaneous carbon dioxide; ETT, endotracheal tube; V_t , tidal volume; MV, minute volume.

CONCLUSION

This study shows that an RFM can be very useful for setting and modifying ventilator variables during stabilisation and transport of ventilated babies. The monitor was easy to use and increased the confidence of the neonatal transport team.

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This study was designed to evaluate equipment already used in the neonatal intensive care units throughout Victoria and therefore parental consent was not sought.

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