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What is the optimal ventilation strategy for children with asthma?

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Background

Asthma is one of the most common diseases in children and despite advances in understanding of physiology, pathophysiology, diagnosis and treatment; it still represents a significant health burden. Whilst most deaths occur in the community, the management of the life-threatening exacerbations requiring mechanical ventilation remains extremely challenging.

Aims

Summarise the evidence supporting optimal management of children with status asthmaticus who have reached the point of needing mechanical ventilation.

Methods

A literature review was performed on OVID Medline and Embase with the following criteria:

1. Asthma* AND
2. P?ediatric* OR child* AND
3. Ventilat*

All articles were reviewed and further references found from manual review of bibliographies.

Findings

Indications for intubation:

- Early recognition of the need for intubation was associated with improved outcomes
- There are various indicators (see table 1) but isolated gases can be misleading as demonstrated by the FISH diagram (figure 1)

Indicators for mechanically ventilating children with status asthmaticus
Cardio-respiratory arrest
Altered mental state/ falling Glasgow Coma Score (GCS)
Hypoxaemia* (despite high concentration of O_2)
Increasing hypercapnia* (despite maximal treatment)
Very severe respiratory distress & inability to speak* (despite maximal treatment)

Table 1: Indicators for mechanically ventilating children with status asthmaticus. *Hypoxia, hypercapnia and respiratory distress by themselves are not indicators for ventilation.

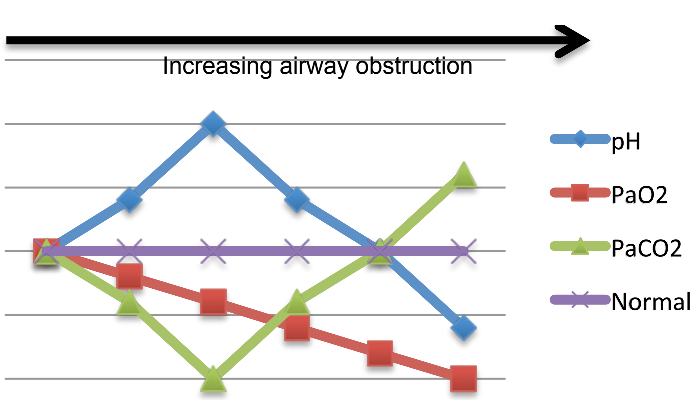

Figure 1: FISH diagram demonstrating how pH, PaO2 and PaCO2 change with increasing airway obstruction (from left to right along the x axis). PaCO2 initially falls with subsequent rise in pH. As decompensation occurs, the PaCO2 continues to rise and pH continues to fall. PaO2 gradually reduces with increasing obstruction. (PaO2 is the partial pressure of oxygen in arterial blood; PaCO2 is the partial pressure of carbon dioxide in arterial blood).

Findings…ctd

Nasal versus oral intubation

- Oral route preferred due to larger airway, less resistance, easier secretion removal, less trauma, sinusitis & bleeding

Ventilation strategy

- Strategies focus on preventing dynamic hyperinflation and consequences of barotrauma and haemodynamic compromise

Mode of ventilation

- In initial stages, controlled modes were preferred as the majority of patients have been working excessively hard & muscles have become fatigued
- Tidal volumes are chosen to keep inspiratory pressures <40cmH_2O,
- Respiratory rate typically set below physiological rate & inspiratory time lowered to allow maximal expiration & avoid dynamic hyperinflation

Permissive hypercapnia

- Permissive hypercapnia with pH >7.2 was found to be well tolerated (alleviates risk of hyperinflation & barotrauma whilst allowing acceptable gas exchange)
- Intrinsic physiological buffer systems have been shown to adequately compensate
- Whilst permissive hypercapnia & mild acidosis is generally well tolerated, it can cause cerebral vasodilatation, cerebral oedema, pulmonary capillary vasoconstriction & reduced myocardial contractility - risks therefore outweigh benefits if post-arrest

Use of PEEP

- Enough PEEP to overcome or equal intrinsic PEEP is preferred to dilate airways, reduce airway resistance & decrease work of breathing

Sedation

- Inadequate sedation is associated with laryngospasm making intubation & subsequent synchonisation more challenging
- Ketamine was deemed the best sedative for its broncho-dilatory effects (but does have side effects of dysphoria, hallucinations & abnormal heart rate & BP with extended use)
- Neuromuscular blockade, although essential at times, should be limited to the lowest effective dose and discontinued as soon as possible to prevent myopathy.

Conclusions

Overall, the mechanical ventilation strategy for children with asthma is generally the same; permissive hypercapnia with pressure limits to prevent barotrauma and low respiratory rate to facilitate a prolonged expiratory phase.

Whilst the literature relating to this area is extensive, the number of asthmatic children ventilated is relatively low. Elucidating the finer details of optimal care requires multi-centre randomised controlled trials but will be limited by the adaptable response required for individual patients. With the development of increasingly sophisticated technology, ventilator auto-adjustments based on plateau pressures and intrinsic PEEP monitoring could be possible.

Once out of the intensive care environment, focus shifts back to optimising prevention. It is imperative follow-up occurs to select the correct therapy for each individual patient and ensure subsequent adherence through education. Whilst optimising ventilation strategies is important, prevention is more likely to significantly impact on overall mortality in asthmatic children.

Full reference list available on request