Use of a Passy-Muir Speaking Valve in a Non-Ventilated Patient

Guideline Development

Tracheostomised infants and children are at risk of speech and language delay

Placement of a tracheostomy tube significantly affects the child’s ability to vocalise due to reduced air-flow through the upper airway.1-3 The presence of the tracheostomy tube in infancy may alter development of the supra-laryngeal vocal tract, resulting in limited tongue movement and altered resonance capacity for vowel production.4

Cannulation typically occurs before the child’s first birthday during the pre-linguistic period.5 The pre-linguistic period occurs prior to the development of spoken words. Contingent vocal response and social feedback to babbling facilitates rapid phonological development during this period.6 Cooing, crying and babbling not only promote attachment7, but also lay the critical neuro-developmental foundations for language learning.6,8 It follows that tracheostomised infants and children are at risk of speech delay2,4,9-13 and language delay.2,7,14

Prolonged cannulation is associated with voice disorder1,2, oral pharyngeal dysphagia2,12,15,16, sensory feeding difficulties2,7,12,16, and behavioural difficulties13. The risk of speech and language delay has been associated with length of cannulation and age at decannulation2,7 and has been found to persist beyond decannulation4,7,11-13. Developing an alternative means of communication, including use of a speaking valve, is considered a vital part of care to facilitate development in tracheostomised children.2,7,9,12,15,17

Wearing the Passy Muir Speaking Valve facilitates voice

The Passy Muir speaking valve (PMV) enables phonation by redirecting exhaled air via the glottis and is considered the speaking valve of choice for children for long term use.18 The PMV has a bias-closed position, compared to the biased-open position of other available valves.19 It remains closed on exhalation and opens only on inspiration. On exhalation, air is redirected through the upper airway, promoting restoration of sub-glottic and glottic pressures and enabling phonation. Aerodynamic analysis of the PMV has indicated an acceptable level of resistance to airflow20,21 and low levels of air-loss in simulated speech.19,21 Successful placement of the PMV has been documented in infants as young as 13 days old.15

PMV placement has been found to improve voice2,7,14,18,22, smell23-25, cough26, and secretion management23,24 as well as improving overall quality of life and well being2,23. Improvements to swallow with PMV placement remain controversial. Several studies have documented improved swallow in the adult population,23,24,26,27 Limited research has been conducted in the paediatric population. Using the PMV is considered an important step to improve comfort and readiness during a decannulation process.9,22,28
Initial Passy Muir Valve trials are often poorly tolerated by Infants and Children

Exhalation via the glottis may be initially uncomfortable and frightening for the tracheostomised patient. A prolonged reduction in airflow through the upper airway following cannulation is associated with drying of pharyngeal membranes and altered laryngeal tone. Adult patients can be warned that PMV placement may be initially uncomfortable and can be educated as to the anticipated benefits of wearing the PMV. For infants and children, it may not be possible to communicate what to expect due to barriers of age and level of cognitive and communication functioning. For infants and children, vocalisation may not be achieved on the first trial, but is usually achieved within three trials.

The success of initial speaking valve placement is related to the child’s physiological and behavioural tolerance. Behavioural resistance is common during initial PMV trials with infants and children. Children commonly respond by coughing, breath-holding, bubble-blowing and forcible exhalations to expel the valve. The physiological success of PMV placement is related to the patency of the upper airway. Upper airway obstruction is the most common reason for paediatric tracheostomy placement. Unfortunately children with upper airway obstruction often have significant difficulty tolerating a PMV.

Manometry Testing is used to discern behavioural from physiological intolerance

The challenge for the examiner is to discern the underlying basis of intolerance. Initial valve assessment traditionally involves monitoring of vital signs; heart rate, peripheral oxygen saturation and work of breathing. Manometry assessment of passive exhalations provides an additional, non-invasive tool for assessment of physiological tolerance. The patency of the upper airway may be inferred using manometry assessment of trans-tracheal pressure. Trans-tracheal pressure (TTP) less than 10cmH\(2\)O on PMV assessment is associated with tolerance of the PMV for short trials. TTP less than 5 cmH\(2\)O has been associated with successful transition to full-day use of the valve, as this indicates the air leak around the tracheotomy tube is large, and the upper airway is patent. Manometry results are superficially inflated if the child attempts to cough or vocalise during assessment.

For a child with TTP<5cmH\(2\)O, intolerance is likely to be behavioural. Families should be educated as to how the valve works, how to monitor the child when using the valve and what to expect. Parental anxiety may transfer to the child, exacerbating distress. It is important that parents have accurate expectations concerning likely behavioural responses to initial PMV placement. A realistic understanding of the child’s current communication skills and likely ability to vocalise should also be communicated. As much as possible, the child should be familiarised with the procedure. For infants, it is recommended that consistent touch cues or Key Word Signs are used, including a warning cue and finish cue.
Physiological intolerance is indicated by dyspnoea and TTP ≥10cmH₂O on passive exhalation. TTP exceeding 10cmH₂O is associated with narrowing of the upper airway or insufficient leak around the tracheostomy tube. Excessive TTP may be adequately reduced by downsizing the tracheostomy tube and thereby increasing the leak to breathe around the tube. However, there are cases where this is either not possible or unsuccessful, with persisting TTP on exhalation. For these ‘failed’ cases, drilling the valve may alleviate excessive TTP whilst still facilitating phonation.

**Drilling a hole in the PMV provides a pressure relief port to reduce trans-tracheal pressure. This may allow comfortable exhalation and enable phonation for children with upper airway obstruction.**

For cases where the tube has been appropriately down-sized and there is known upper airway obstruction, a drilled hole may alleviate excessive TTP whilst still facilitating phonation. This innovative practice was originally described in 1999 and recently in 2009.

The drilling of a speaking valve results in the presence of a relief port to enable partial exhalation through the tracheostomy tube whilst wearing the PMV. Pneumatic benefits to swallow and secretion management obtained through one-way valve use are presumably lost by the presence of the hole. Secretions gather in the tracheostomy tube, requiring removal of the PMV for suctioning. However, vocalisation using the drilled PMV may be achieved due to the presence of an effective relief port in cases where use of a standard PMV would otherwise be contraindicated. Drilling of the valves is standard practice at Cincinnati Children’s Hospital Medical Centre and Boston’s Children’s Hospital but is not yet well described in the literature. Drilled valves have been trialled with ten cases at PMH with promising results.

**PMH Retrospective Case Series: Drilling a PMV to promote Tolerance and Phonation**

A retrospective case series audit was completed reviewing ten charts of tracheostomised children trialled with a drilled speaking valve over the period between January 2008 and January 2010. Ethics approval was gained through the hospital Governance board (Reference 127QP).

Patients were tracheostomised infants and children aged 2 months – 15 years (mean: 3 years 2 months; median 19 months) who had significant upper airway obstruction at a laryngotracheal level, some had additional obstruction at a supralaryngeal level. All patients were aphonatic.

The included patients had failed a trial of a standard PMV with TTP range >10cmH₂O on passive exhalation as measured using a handheld manometer. Downsizing of the tracheostomy tube was either already completed or inappropriate. Referral and permission for trial of a drilled speaking valve was received from the child’s ENT surgeon and their guardians. Patients were excluded if their upper airway diagnosis was too severe (e.g. Grade 4 subglottic stenosis) or if the patient was medically unstable, unable to tolerate cuff deflation or had severe oral aversion.
The trial of the standard and drilled speaking valves was conducted within a single session. Patients were assessed wearing a Passy-Muir valve with up to two 1.6 mm holes drilled in the side of the valve. Patients progressed to trials if trans-tracheal pressures measured less than 10cmH20.

Eight patients progressed to trial with 5 of 8 patients able to phonate within one week and 6 of 8 able to tolerate wearing the valve for $\geq$2 hours periods within 2 weeks of introduction. All eight patients were able to phonate within six months of valve introduction.

These findings support drilling Passy-Muir speaking valves as a promising option to facilitate phonation in tracheostomised children with upper airway obstruction, with potential positive implications for speech and language development.

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