Comparison of bubble CPAP systems intended for neonatal use in low-income countries: Consequences on performance when deviating from the original design

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Not all bubble CPAP systems perform the same

High resistance interfaces, large dead space and narrow bore expiratory tubing were identified as potentially harmful modifications of Bubble CPAP that warrant concern (Fig 1).

Background

The original bubble CPAP as described by Wung et al (1) consists of a low resistance interface directly connected to wide bore expiratory (bubble) tubing. Several modifications of this design, aimed for use in low-income countries, are available. We have previously identified dead-space and the risk of rebreathing when using long, connecting tubing between interface and system (2). Other design alterations are high resistance interfaces and narrow bore expiratory tubing.

The aim of this study was to review deviations from the original design and test the effect of interface resistance and the diameter of expiratory tubing.

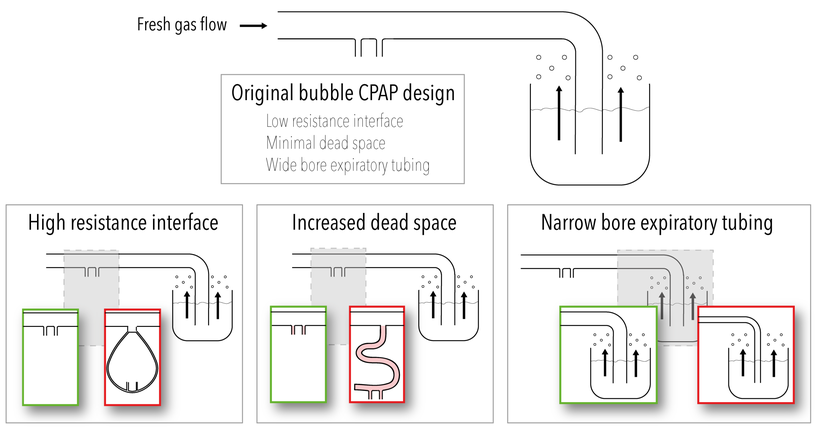

Figure 1: Summary of deviations from the original bubble CPAP system of clinical concern.

Methods

Using a test lung (IngMar Medical, Pittsburgh, USA) with simulated infant breathing (32 ml, RR 60) expiratory tubing (1.5 m and 3-12 mm inner diameter) was tested with Hudson (size 4) and Fisher & Paykel prongs (size 5040) and RAM cannula (size infant - orange) at a CPAP of 5 cm H_2O and fresh gas flows of 6 and 8 L/min.

Results

With smaller internal diameters, the expiratory tubing resistance increased and the mean CPAP was higher than the submersion depth indicated. The increase in mean CPAP was greater with higher fresh gas flows (Figure 2). Using expiratory tubing with a smaller internal diameter or interfaces with high resistance increased the work of breathing (Figure 3).

Conclusion

We identified three deviations from the original Bubble CPAP design that alter the basic properties of the device and are of clinical concern: high resistance interface, large dead space and narrow bore expiratory tubing.

Deviating from the original design may result in unintentional high CPAP that is not reflected by submersion depth and increased resistance to breathing.

Our tests suggest, for neonatal use, that this can be avoided by using a low resistance interface and expiratory tubing with an inner diameter greater than 8 mm. To avoid carbon dioxide accumulation, dead space should be avoided.

Limitations

All tests were performed in-vitro and without leakage. In a clinical setting delivery of excessive CPAP will be limited by increased leakage. Other important aspects of CPAP care not discussed in this poster are gas delivery and conditioning, nursing and comfort aspects, costs and logistics.

1. Sahni R, Wung J. Symposium : Advances in Neonatology-II Continuous Positive Airway Pressure (CPAP). 1998;265–71.
2. Brown J, Machen H, Kawaza K, Mwanza Z, Iniguez S, Lang H, et al. A High-Value, Low-Cost Bubble Continuous Positive Airway Pressure System for Low-Resource Settings: Technical Assessment and Initial Case Reports. Semple MG, editor. PLoS One. 2013 Jan 23;8(1):e53622.

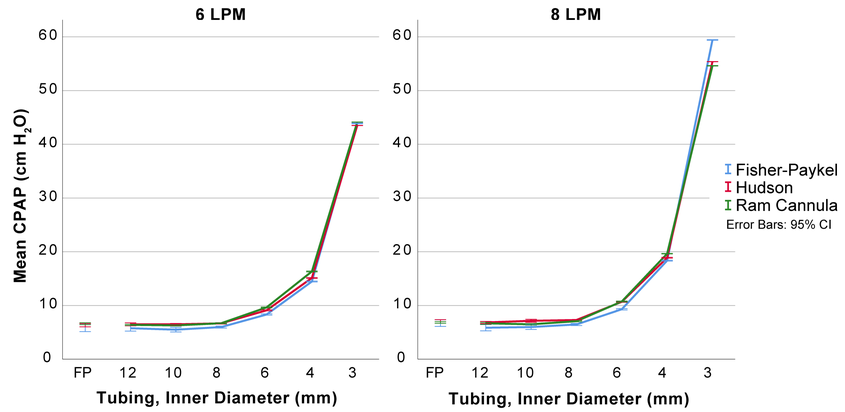

Figure 2: Effect of narrow bore expiratory tube resistance. Mean CPAP for 3-12 mm diameter expiratory tubing with three interfaces at 5 cm of submersion and with two levels of fresh gas flow. Fisher-Paykel original expiratory tubing added for reference.

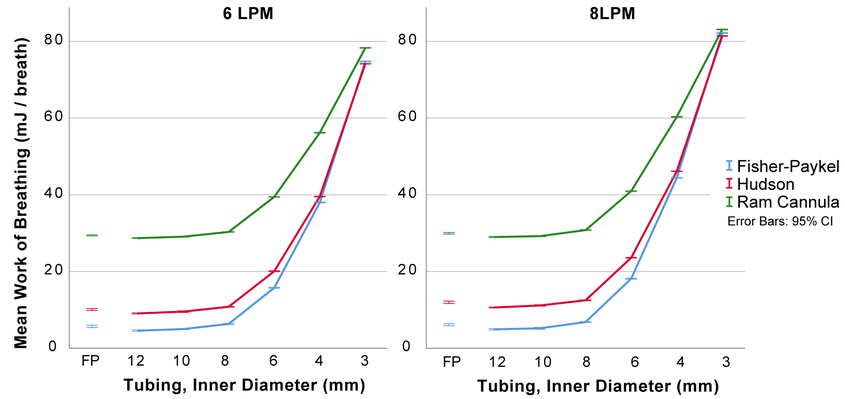

Figure 3: Effect of interface resistance. Imposed work of breathing for 3-12 mm diameter expiratory tubing with three interfaces at 5 cm of submersion and with two levels of fresh gas flow. Fisher-Paykel original expiratory tubing added for reference.

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