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RAM® Pressures: What You See is Not What You Get

Rob Graham, R.R.T./N.R.C.P.

I dedicate this column to the late Dr. Andrew (Andy) Shennan, the founder of the perinatal program at Women's College Hospital (now at Sunnybrook Health Sciences Centre). To my teacher, my mentor and the man I owe my career as it is to, thank you. You have earned your place where there are no hospitals and no NICUs, where all the babies do is laugh and giggle and sleep.

RAM® cannulae have been available to clinicians for several years. They have been used as an alternate interface to conventional continuous positive airway pressure (CPAP) interfaces, especially where there is evidence of compromised skin or nasal septal integrity and a primary interface for high flow (HF) administration.

Debate rages around whether or not this device delivers "real" CPAP, whether HF delivers real pressure, and, if so, how much. Intuitively clinicians have increased the set CPAP pressure to compensate for an assumed pressure loss through the prongs, but there is no data indicating how much it should be increased.

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A study comparing different interfaces, including RAM®, revealed increased pressure setting requirements for both CPAP and non-invasive positive pressure ventilation (NIPPV), but the settings used were minimal. (1) Typical RAM® settings have been 2 cm-H_2O higher than "conventional" CPAP pressure, but some babies do not seem to tolerate the interface at those pressures. Pressure may be increased to clinical effectiveness, but again we have (to the best of my knowledge) no idea as to what the limits are to either CPAP or HF settings; or how linear the delivered vs. set pressures are as pressure or flow is increased. One study compared delivered oropharyngeal pressure obtained with conventional CPAP vs. RAM®, and it showed significantly lower pressure delivery with the latter interface, as well as greater breath to breath pressure variation. (2)To roughly estimate the delivered pressure through RAM® cannulae and assess the linearity of delivered pressure, I conducted a bench study using a Sechrist® Airway Pressure Monitor Model 400 and a Drager Babylog VN-500® ventilator set on either CPAP or oxygen therapy mode. (see Figure 1).

Pressure lines of equal length and diameter were used with the RAM® prongs inserted into the pressure lines. One line was left open to the air to simulate normal anatomical leakage. (Without the second pressure line measurements at the prongs themselves was zero). Measured pressure at the nasal prongs from the first pressure line was taken using each of the three-prong sizes: preemie, infant, and newborn.

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Pressures were measured stepwise from CPAP of 7 - 15 cmH_2O, and high flow settings of 4 – 12 lpm. The ventilator could not provide flow higher than 12 lpm without pressure dumping. The resulting measurements are charted for CPAP in figure 2 and HF in figure 3.

A CPAP level of less than 5 cmH_2O is generally regarded as ineffective and is not used in the unit in which I practice. It is generally accepted that naturally occurring PEEP in spontaneously breathing, non-intubated patients is at least 2 cmH_2O, as a result of pressure generated by chest recoil against a closed glottis. While I could find no reference to support this, it stands to reason some physiologic PEEP must be present to prevent alveolar collapse and "sticky atelectasis". Maintaining alveolar patency is important to preserve surfactant function. It is possible this pressure is less in the premature infant due to decreased chest recoil.

In clinical practice, I would not use a CPAP level of less than 5 cmH_2O. These results indicate that a set CPAP level of less than 7 cmH_2O or a HF flow rate of less than 5 – 6 lpm using the RAM® interface would deliver sub-therapeutic pressures. Delivered pressure increased linearly with increasing set CPAP pressure (but not stepwise), and setting CPAP at double the pressure, did not double the delivered pressure. Delivered HF pressures increased exponentially with increasing flow rates to the limit of the ventila-

tor's ability to do so without pressure dumping.

In CPAP mode, delivered pressure showed a small but consistent decrease in delivered pressure as prong size increased; however, this was not the case in HF mode. Ideally, intra-nasal or esophageal pressures should be measured to determine in vivo pressures and to determine the effects of spontaneously breathing on delivered pressure. This would require ethics approval and consent. That said, these measurements could be used as a guide for pressure setting in conjunction with clinical response and appear to match the 60-70% pressure delivery with RAM® found in another study. (3) The study also found that with a leak of >50%, negligible pressure was delivered to the simulated lung.

In intubated, conventionally ventilated patients, it is becoming accepted that the upper inflection point of the pressure-volume loop represents the point of optimal PEEP.(4) If these measurements could be reliably taken while on non-invasive CPAP, it would greatly aid in establishing a proper CPAP level.

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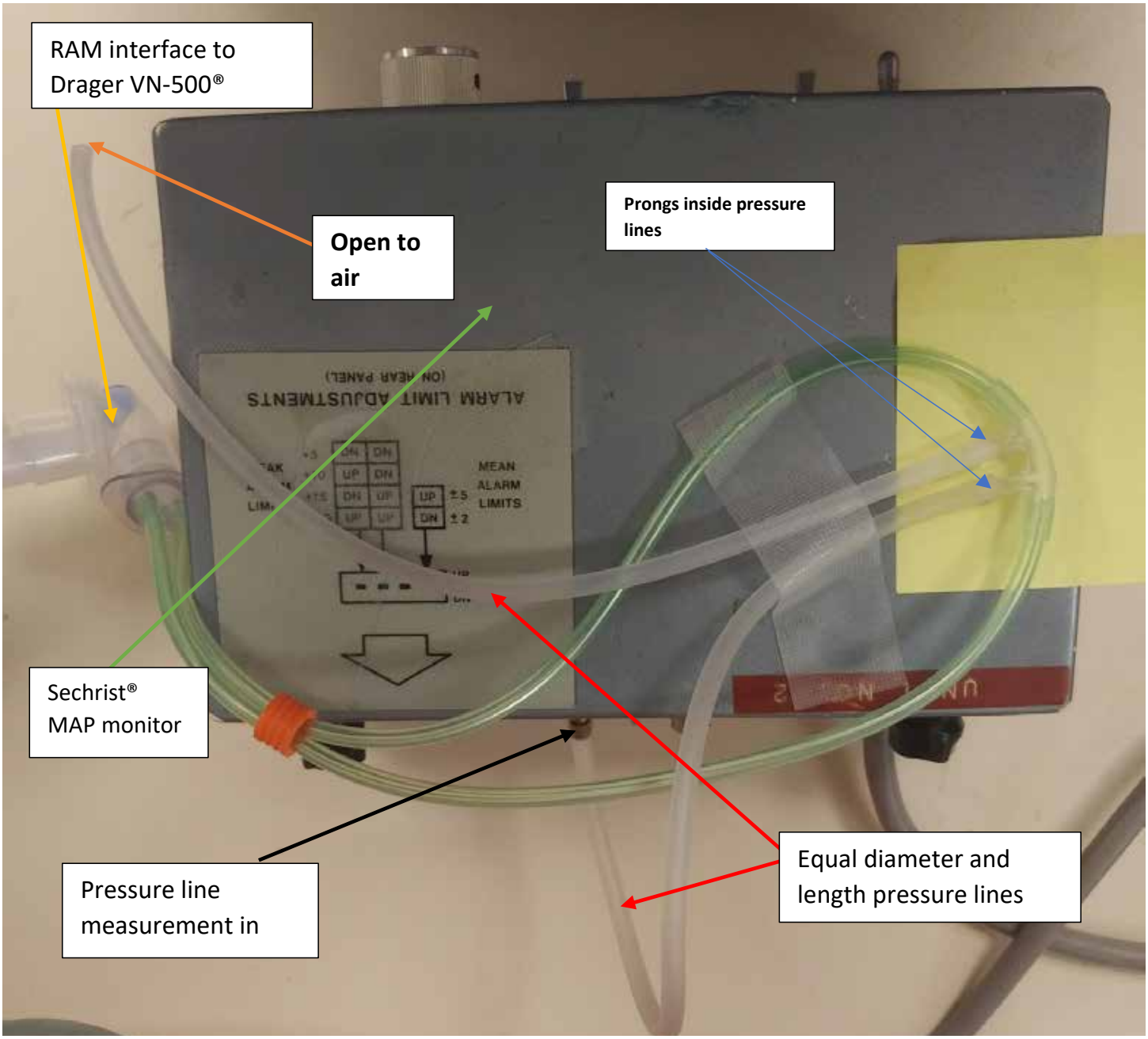
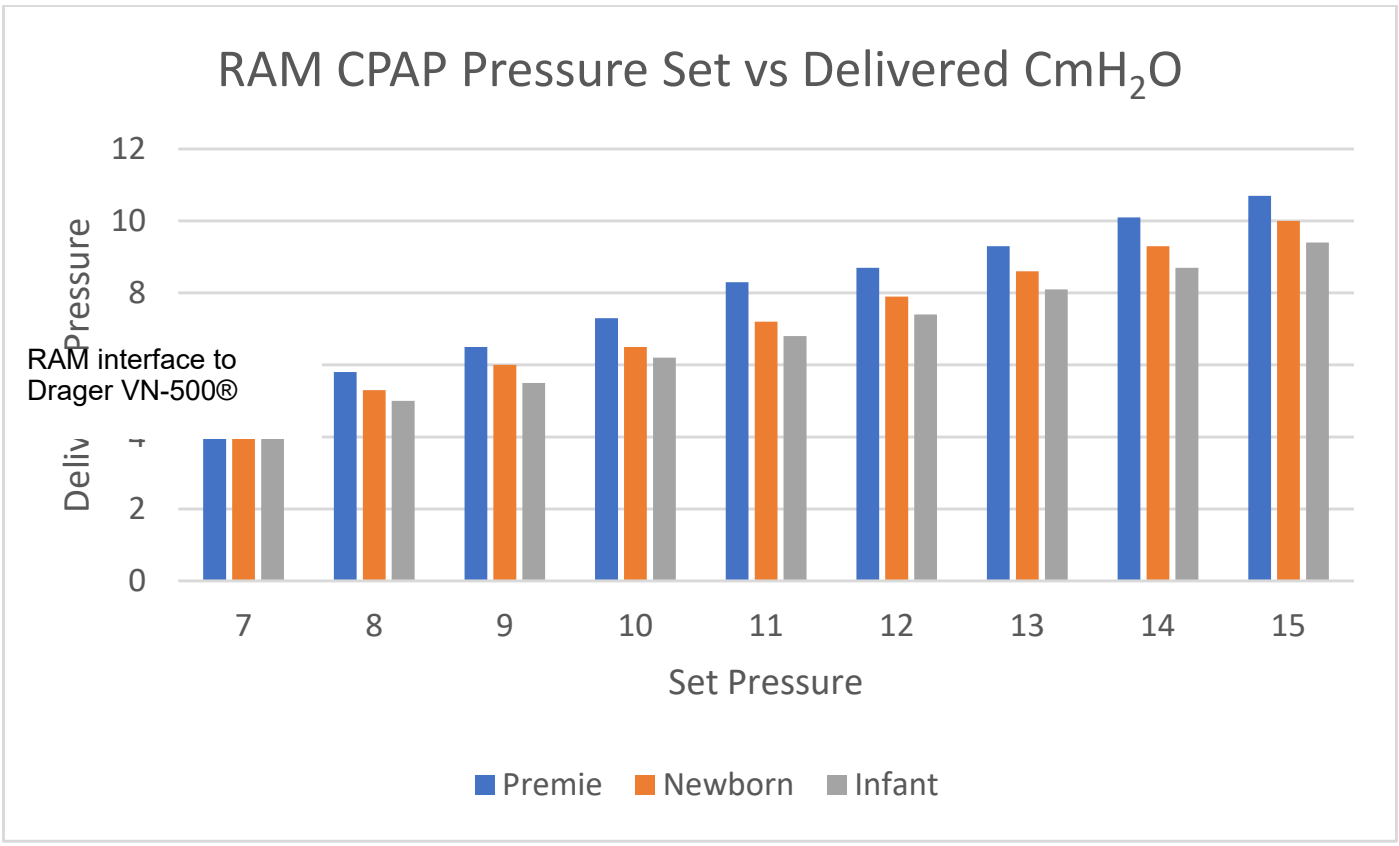


Figure 1: pressure measurement setup



Prongs inside pressure lines

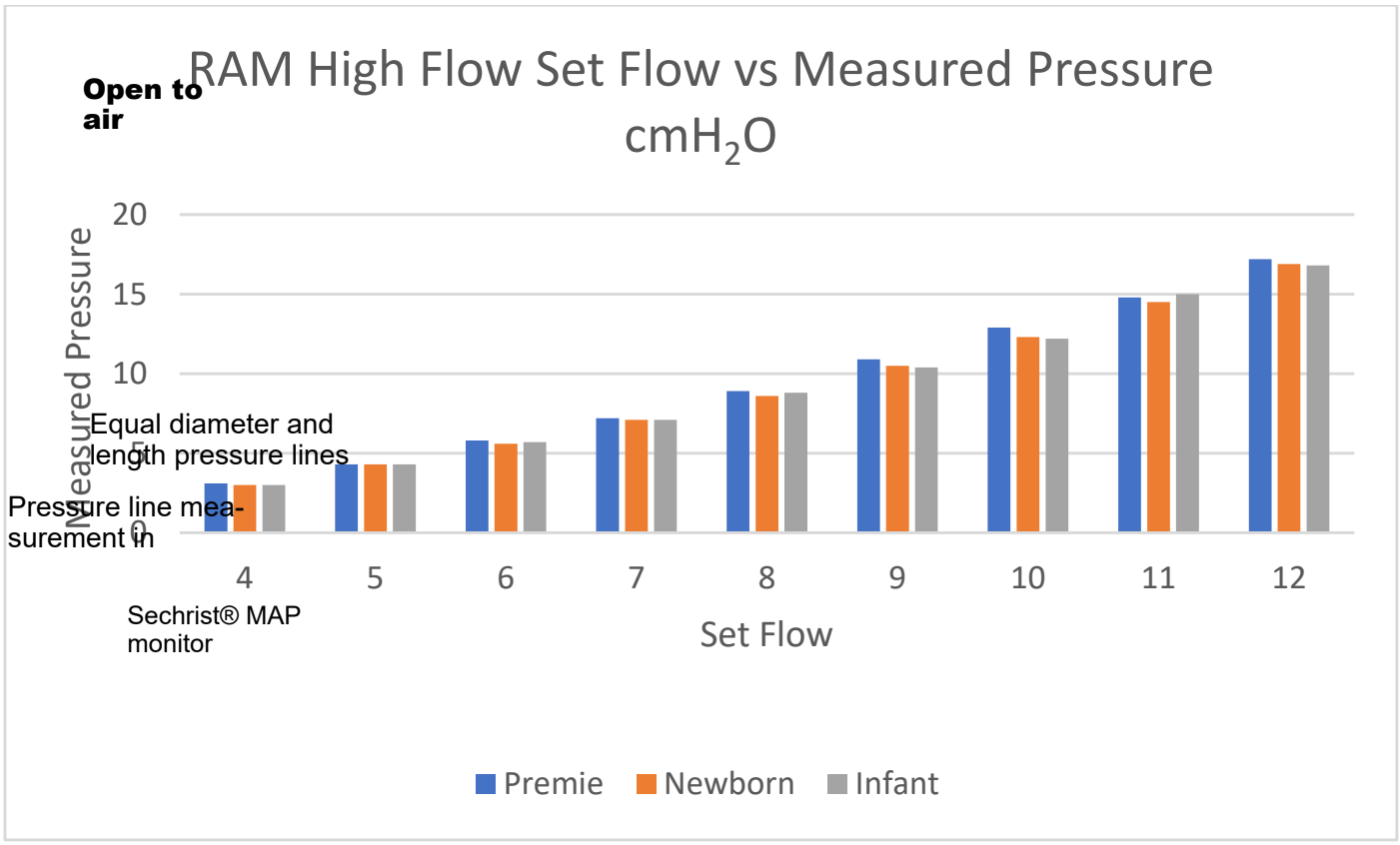


Figure 2: CPAP set vs delivered pressure from RAM cannulae

Figure 3: High flow RAM cannulae delivered pressure

Electrical diaphragmatic impedance (EDI) has been used clinically to guide optimal PEEP levels in mechanically ventilated patients and has predicted the likelihood of successful extubations. (This was done during initial evaluation in a study setting). EDI holds great promise for providing aid to clinicians in finding proper CPAP levels in intubated and non-intubated patients. This is a relatively new technology and is not readily available in many NICUs at present.

In summary, RAM® cannulae are widely used in clinical practice and are a viable option to other interfaces. Clinicians must be aware of, and compensate for, the delivered pressure difference. Clinicians must also take into account the limitations of flow and pressure delivery to improve success.

References:

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