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FACT SHEET

Understanding Neonatal Non invasive ventilation: Part 1

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Introduction

Many of the babies admitted to the neonatal unit require some degree of respiratory support at varying levels for a given time period as dictated by individualised assessment of their overall condition. This Fact Sheet, following on from Oxygen therapy by Fallon (2012), offers an overview of current *non-invasive* ventilation practice in neonatal care focusing on the terms and modes used. The aim is for the reader to understand the range of strategies used to support the neonate's respiratory system in line with the relevant evidence for delivery of best practice for the neonate and family.

Respiratory management in the context of neonatal care

Neonates require ventilator support to augment their own respiratory system when this is unable to provide adequate support and gaseous exchange during respiratory compromise or failure. The aim of any neonatal respiratory support strategy is to achieve adequate gaseous exchange without lung injury: in other words, the goal must be a healthy neonate and child with no resultant chronic lung disease (Bellettato et al, 2011), one of the potential and significant long-term effects of prolonged mechanical ventilation in the neonatal period.

Ventilation support can be viewed within the framework of dependency levels as described by BAPM (2010) and the DoH (2009):

1- Special care: A neonate in special care may not require any respiratory support and may simply be observed if there is a suspected or actual concern at birth or they may receive a low percentage and / or flow of oxygen due to mild or recovering respiratory compromise or disease.

2- High Dependency: A neonate in high dependency requires a greater level of support and may receive modes such as continuous positive airway pressure (CPAP), Biphasic pressure and / or high flow oxygen therapy, again as dictated by their condition.
3- Intensive care; A neonate in intensive care in many cases will require full ventilation for a given time period either by conventional or non-conventional means.

A neonate can be admitted to any of these three levels or they may experience all of them during their neonatal unit stay. As an example, the sickest neonate is generally admitted to intensive care for full ventilator support. The subsequent journey through the neonatal unit then involves them progressing to high dependency when their condition allows and when they are able to be extubated to CPAP or Biphasic pressure. Thereafter the aim is for them to progress to special care where they may still require oxygen therapy. As their need for support for their respiratory and other systems lessens and their condition improves, they will then be able to wean off oxygen to be discharged home at an appropriate time.

Overview of non-invasive respiratory support strategies in the neonatal unit

Explanations of the strategies will now be given according to the above dependency levels from 1 through to 3.

OXYGEN THERAPY: Supplementary oxygen in self ventilating neonates can be delivered by various means depending on the oxygen requirement. If requirements are relatively low, then ambient oxygen can be given into an incubator or via a head box with the use of an oxygen analyzer to measure the percentage administered. For longer term delivery, low flow (less than 1 litre / minute) nasal cannula oxygen is given and weaned down slowly until the neonate is able to ventilate in room air. In addition, high flow (1-8 litres/ minute) nasal cannula oxygen therapy has recently been introduced in the form of the Vapotherm © device (Image 1). This is a thermally controlled humidification system (at 95% or greater relative humidity) that flushes nasopharyngeal dead space. It is documented that this therapy can be suitable as an alternative to continuous positive airway pressure (CPAP), for neonates with nasal injury or for those who are very unsettled from prolonged CPAP (Lawn, 2007). Research in this therapy within the adult field is overall positive and as Lawn reports, the benefits from one unit's experience in neonates is clear. Although work is emerging on this therapy in neonates, further research is required to substantiate benefits (Hochwald and Osiovich; 2010; Wilkinson et al, 2008; Wilkinson et al, 2011).

High flow oxygen via this method is one of the 'non-invasive' strategies available, a vitally important concept in neonatal ventilation practice given the potential damaging effects of full respiratory support by endotracheal intubation and long term ventilation. This will be addressed in more detail in a later Fact sheet. Most commonly used in clinical practice in relation to non-invasive intervention is continuous positive airway pressure (CPAP).

Image 1: High Flow oxygen Vapotherm device © Source:

CPAP: A constant positive pressure is applied to the airway of a spontaneously breathing neonate to maintain adequate functional residual capacity within the alveoli and prevent atelectasis. In current practice, binasal CPAP has superseded the single nasal prong and is administered non-invasively by a Flow driver via two short prongs (see images 2 and 3) or nasal mask. DePaoli et al (2008) report on this method being preferable to single prong use when delivered by a flow driver. The device used to deliver the gases to the neonate's nose is designed to support the baby's breathing throughout the respiratory cycle in that there is a special ‘flip’ mechanism. This is best explained in the following Table taken and adapted from the product information provided by Carefusion (2012) as follows:

Table 1: Explanation of the ‘flip’ mechanism in the Flow driver
Inspiratory flow; The flow provided by the Infant Flow SiPAP system is accelerated in the twin injector nozzles of the Infant Flow generator. When the baby makes a spontaneous inspiratory effort, the Flow generator converts the kinetic energy of the flow to pressure, thereby reducing the work of breathing and maximizing pressure stability at the baby interface. **Expiratory flow;** When the baby exhales, the forward velocity of the airflow decreases. This allows the gas flow to “flip” from the nasal prongs to the expiratory tube and this continuous gas flow provides residual gas pressure enabling stable CPAP pressure delivery throughout the respiratory cycle. When expiratory effort stops, the flow instantly flips back to the inspiratory position.

Davis and Henderson Smart (2003) also report how binasal CPAP prevents failure of extubation. Given the relationship between flow and pressure, generally, a flow of 8-10 litres / minute should give a pressure of 4-6 cm / water (see image 2) provided that there is an adequate seal at the nostrils. Altering the flow will affect the pressure given. For some neonates, it is necessary to increase the flow to give a higher pressure of 6-7 cm / water (subject to individual assessment by ward medical / nursing team). Once the baby’s lungs improve, the flow and subsequent pressure can then be reduced according to the baby’s condition and or the neonate can ‘cycle’ on and off for agreed periods of time until able to tolerate ventilating without pressure. Jardine et al (2011) found that weaning from CPAP takes less time by reducing the pressure down gradually to an agreed value and then stopping rather than the ‘cycling’ method. However, in practice decisions are guided by the individual neonate’s condition.

Image 2: Neonate on binasal Flow driver CPAP
Source:

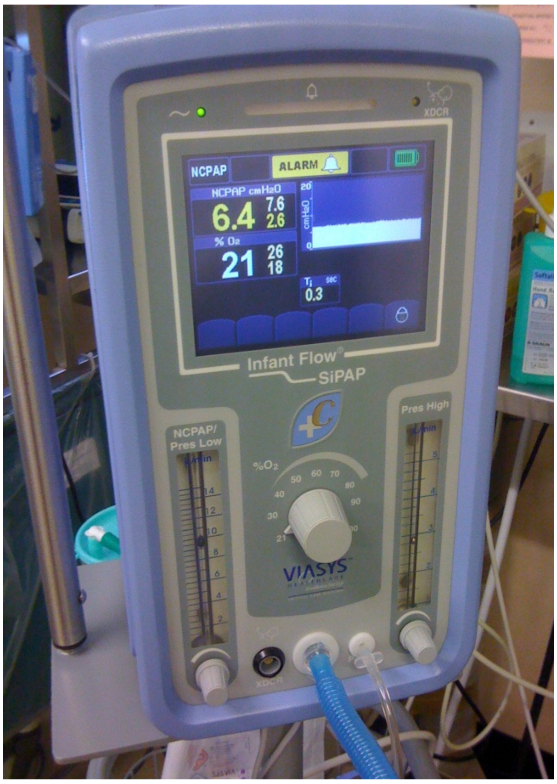

Image 3: Flow driver CPAP Source; J Petty

Bi-phasic positive airway pressure (BIPAP) is where two pressure levels are set, a background continuous measurement and a higher one which is delivered at intervals either triggered by the neonate or set as a mandatory 'rate'. Infant flow SIPAP © provides bi-level nasal CPAP for the spontaneously breathing neonate through the delivery of 'pulses' or 'sighs' (brief periods of increased pressure) above a baseline CPAP pressure (See image 4). These may be timed, or 'triggered' by neonates own inspiratory efforts. (Bhandari, 2010). Literature often refers to the setting of these positive pressure 'sighs' as nasal intermittent positive pressure ventilation (NIPPV; Sweet, 2008; Owen et al, 2008), not to be confused with intermittent positive pressure ventilation or IPPV via full intubation as will be covered shortly. A study by Khalaf et al (2001) found that NIPPV is more effective that NCPAP in weaning neonates with respiratory distress syndrome. A meta-analysis of three studies comparing NIPPV and CPAP after neonates were extubated found a reduction in re-intubation rates in the former group (Davies et al, 2001)and more recently Lista et al (2010) report, following a randomized controlled trial comparing single and bi-level CPAP, found the latter group was associated with improved respiratory outcomes allowing earlier discharge. However, Meneses et al (2011) found that early NIPPV did not decrease the need for mechanical ventilation compared with NCPAP, overall, in the first 72 hours of life. Owen et al (2011) also found no differences between the two in relation to the variations in pressure concluding that it is probably the increase in *overall* pressure that is beneficial.

Image 4: Bi-phasic screen showing 2 levels of support
Source:

Glossary of modes

CPAP–CPAP is a mode itself on all ventilators as well as support strategy in it's own right known as nCPAP (nasal CPAP). On the Flow driver ©, it can be given with or without 'apnoea'. If CPAP with apnoea is required, then an abdominal transducer is necessary in order to monitor any apnoeic episode and raise the alarm according to the apnoea time interval which is set by the user. On the older Flow driver module that just delivers one level of CPAP, generally a flow is set to 8 litres / minute to aim for a pressure of 5-6 cm / H20 (again subject to assessment of the individual baby). The humidifier should be set to deliver gases at 37 degrees Celcius to the baby's airway.

BIPAP- BIPAP has the following mode options namely:

- Biphasic timed; The machine delivers a set baseline pressure using the '*high* pressure' flow metre (set to 8 L/minute on average). The extra pressure supported 'sighs' are delivered according to a set ‘rate’ and Ti. The user will set the additional pressure with the ‘*low* pressure’ flow metre and will set the number per minute and length of each extra sigh.

- Trigger Biphasic; As above but the extra pressure sighs are not timed. These are now triggered by the neonate initiating a breath.

- BiPhasic + apnoea - as for biphasic times but there is additional apnoea monitoring and an alarm will sound if the neonate does not breathe within the apnoea interval, as for CPAP and apnoea above.

- Flow – there are 2 flow meters (See Image 4) on the ‘SIPAP’ model. The left one pictured is known as ‘low’ pressure where the CPAP pressure is set. The right hand one is ‘high’ pressure which is set 2 litres / minute above the low pressure dial. This is what delivers the *second* or *additional* pressure when bi-phasic mode is required. It is important not to set the ‘high pressure’ flow too high.

When delivering ventilator support to neonates, it is important to be aware of the potential negative effects of ventilation (Claure and Bancalari, 2007); for example: lung injury from barotrauma (pressure) and / or volume leading to chronic lung disease, oxygen toxicity, hypotension, and lung hyperinflation and nosocomial respiratory infection. Bedside assessment and monitoring is the key to ensuring any negative effect is identified as soon as possible – e.g. CXR findings, blood pressure. Bedside care must keep the negative effects in mind such as avoiding high oxygen concentrations, supporting the BP and continuous 02 monitoring.

Current respiratory support strategies must also have these dangers as a central consideration. Overall protective lung strategies that include the use of non-invasive ventilation modes should be employed as appropriate from the point of birth and beyond. Surfactant and non-invasive modes such as CPAP (Davies et al, 2009)and biphasic ventilation has significantly influenced the current ethos behind the support of preterm neonates with respiratory failure (DiBlasi, 2011), Recent European Guidelines for the management of preterm neonates born with RDS recommend very early Surfactant followed by extubation to CPAP as a way of potentially reducing lung damage (Sweet et al, 2007) and this is an area of current interest (SUPPORT Study Group, 2010). The use of early delivery room CPAP is also well documented (Finer et al, 2004; tePas et AL, 2007). The Newborn life Support Guidelines (UK Resuscitation Council, 2010) support the use of positive end pressure in the stabilisation of preterm babies at delivery as required. As, Mulder et al (2012) put forward for discussion, the advent and increasing use of non-invasive ventilation strategies should lead to a significantly reduced incidence of chronic lung disease from prematurity.

Conclusion

Technological advances have resulted in improvements in ventilation strategies that offer a wider range of non-invasive modalities. Knowledge of the terms used in neonatal clinical respiratory practice is valuable since this practice comprises a significant proportion of care given to sick neonates within the neonatal unit. It is not possible to cover within the scope of this paper, the nursing care given to the neonate receiving the above mentioned strategies; this will be the subject of a future edition. Those caring for such sick and vulnerable neonates owe it to them and their families to have a full understanding of common but often complex practice while at the same time work towards minimising any resultant damage and respiratory morbidity. This is not only so that care is supported by best evidence based rationale but also so that parents can be given information about the strategies their babies receive and outcomes, a vital component of true holistic family centered neonatal care.

Note Subsequent Fact Sheets will follow on from the current topic in future editions; namely, the nursing care for neonates on non-invasive respiratory support and an overview of invasive mechanical ventilation in the neonatal unit.

References

Bellettato B, Carlo W, Rosenkrantz T, Carter BS and Windle. ML. *Assisted Ventilation of the Newborn*. 2011 http://emedicine.medscape.com/article/979268-overview (accessed 24th October 2012)

Bhandari, V. Nasal Intermittent Positive Pressure Ventilation in the Newborn: Review of Literature and Evidence-based Guidelines J Perinatol © 2010 Nature Publishing Group http://www.medscape.com/viewarticle/726907 (accessed 28th September 2012)

British Association of Perinatal Medicine (BAPM). *Standards for hospitals providing Neonatal Intensive and High dependency care (2nd edition)*. 2010, BAPM, London

Carefusion (2012) *Taking Neonatal Non-invasive ventilation to the next level*
Carefusion; Yorba Linda, CA
http://www.carefusion.com/pdf/Respiratory/Ventilation/Infant_Flow_SiPAP_brochure_RC1797.pdf

Claure N and Bancalari, E. New modes of mechanical ventilation in the preterm newborn: evidence of benefit *Arch Dis Child Fetal Neonatal Ed* 2007; 92: F508-512

Davis PG, Lemyre B, De Paoli AG. Nasal intermittent positive pressure ventilation (NIPPV) versus nasal continuous positive airway pressure (NCPAP) for preterm neonates after extubation. Cochrane Database of Systematic Reviews 2001, Issue 3. Art. No.: CD003212. DOI: 10.1002/14651858.CD003212.

Davis PG, Morley CJ, Owen LS. Non-invasive respiratory support of preterm neonates with respiratory distress: continuous positive airway pressure and nasal intermittent positive pressure ventilation. *Semin Fetal Neonatal Med*. 2009; 14: (1), 14-20.

Department of Health (DoH). *Toolkit for High Quality Neonatal Services*. 2009 The Department of Health, London

DiBlasi RM. Neonatal Noninvasive Ventilation Techniques: Do we really need to intubate? *Respiratory Care*. 2011; 56: (9), 1273-1297.

Lawn. C. High Flow humidified oxygen therapy for neonates requiring respiratory support *Infant* 2001; 3: (3), 105-108

De Paoli AG, Davis PG, Faber B, Morley CJ. Devices and pressure sources for administration of nasal continuous positive airway pressure (NCPAP) in preterm neonates. Cochrane Database of Systematic Reviews 2008, Issue 1. Art. No.: CD002977. DOI: 10.1002/14651858.CD002977.pub2.

Davis PG, Henderson-Smart DJ. Nasal continuous positive airway pressure immediately after extubation for preventing morbidity in preterm infants. Cochrane Database of Systematic Reviews 2003, Issue 2. Art. No.: CD000143. DOI: 10.1002/14651858.CD000143.

Fallon A (2012) *Fact Sheet Oxygen Therapy* Journal of Neonatal Nursing

Finer NN, Carlo WA, Duara S, et al. Delivery room continuous positive airway pressure/positive end-expiratory pressure in extremely low birth weight infants: a feasibility trial. *Pediatrics*. 2004; 114: (3), 651-7.

Greenough A, Donn SM. Matching ventilatory support strategies to respiratory pathophysiology. *Clin Perinatol*. 2007;34: (1), 35-53, v-vi.

Hochwald O and Osiovich H., The use of high flow nasal cannulae in neonatal intensive care units: Is clinical practice consistent with the evidence? *Journal of Neonatal-Perinatal Medicine* 2010. 3 (3), 187-191

Jardine LA, Inglis GDT, Davies MW. Strategies for the withdrawal of nasal continuous positive airway pressure (NCPAP) in preterm infants. Cochrane Database of Systematic Reviews 2011, Issue 2. Art. No.: CD006979. DOI: 10.1002/14651858.CD006979.pub2.

Khalaf MN, Brodsky N, Hurley J, Bhandari V. A prospective randomized, controlled trial comparing synchronized nasal intermittent positive pressure ventilation versus nasal continuous positive airway pressure as modes of extubation. *Pediatrics*. 2001;108: (1):13-7.

Lista G, Castoldi F, Fontana P, et al. Nasal continuous positive airway pressure (CPAP) versus bi-level nasal CPAP in preterm babies with respiratory distress syndrome: a randomised control trial. *Arch Dis Child Fetal Neonatal Ed*. Mar 2010; 95:(2):F85-9.

Mulder. EEM, Lopriore. E, Rijken. M Walther. FJ and te Pas. AB. Changes in Respiratory Support of Preterm Infants in the Last Decade: Are We Improving? Neonatology 2012; 101:247-253 (DOI: 10.1159/000334591)

Owen LS, Morley CJ, Davis PG. Neonatal nasal intermittent positive pressure ventilation: a survey of practice in England. *Arch Dis Child Fetal Neonatal Ed* 2008; 93: F148-F150.

Resuscitation Council UK (2010) Newborn Life Support http://www.resus.org.uk/pages/nls.pdf

SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network. Early CPAP versus Surfactant in Extremely Preterm Infants *New England Journal of Medicine* 2010; 362: 1970-9

Sweet D., Bevilaqua G., Carnielli V. et al. European Consensus Guidelines on the management of neonatal respiratory distress syndrome. *J Perinatal Med* 2007; 35: 175-86.

Sweet, D. Synchronised Nasal ventilation – Where are we now? *Infant* 2008; 4: (2), 40

te Pas AB, Walther FJ. A Randomized, Controlled Trial of Delivery-Room Respiratory Management in Very Preterm Infants. *Pediatr*. 2007; 120: 322-329.

Wilkinson DJ, Andersen CC, Smith K, Holberton J. Pharyngeal pressure with high-flow nasal cannulae in premature infants. *J Perinatol* 2008;28 (1), 42-47.

Wilkinson D, Andersen C,O'Donnell CPF,De Paoli AG. High flow nasal cannula for respiratory support in preterm infants. *Cochrane Database of Systematic Reviews* 2011, Issue 5. Art. No.: CD006405. DOI: 10.1002/14651858.CD006405.pub2.