Respiratory guidelines for neonatal HAMILTON-G5 use

For the NICU of Children's Hospital Colorado (Colorado Springs, USA).

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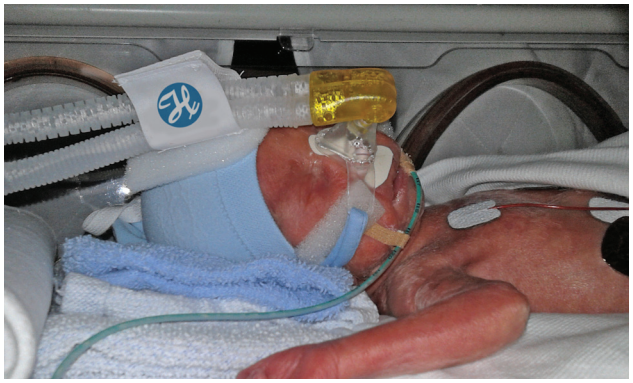
Introduction

This document was created by a multidisciplinary team for the purpose of having a common practice- and unit-wide approach to management of respiratory support. Having a common approach will facilitate our evaluation of clinical effectiveness and implementation of quality improvement processes. There are two important principles regarding this document:

1. These are guidelines, not protocols or requirements. There will be many clinical situations that will require individualized treatment plans; however, by being systematic we hope to continually improve the guidelines to accommodate more situations.

2. This is intended to be a living document that will be regularly revisited and revised as dictated by clinical experience and evolving medical evidence.



nCPAP management

1. The preferred format for CPAP orders should include one target value (i.e., 5 cmH_20). Nasal CPAP orders should not contain a range of values (i.e., 4–6 cmH_20). It is understood that actual CPAP pressure will vary. Ordering a target value will optimally decrease the variation in the range of actual CPAP pressure delivered.

2. nCPAP should preferably be delivered via HAMILTON-G5 ventilator for the following:

    - Any unstable infant with possible need for higher level of support.
    - Neonates ≤ 1500 g when a HAMILTON-G5 ventilator is available. The HAMILTON-G5 has more flexibility and greater capabilities for delivering CPAP for this patient population than the Aladdin devices we currently use. In addition, there is a higher likelihood of CPAP failure and need for intubation, and this will allow for the use of the same support equipment after the transition.
    - The HAMILTON-G5 is a flow-compensating CPAP device. This allows more consistent delivery of pressure under a variety of clinical conditions, including air leak. Please note that even if the interface is completely off the patient, the data may continue to show some pressure due to the attempt to compensate for the "leak".

Non-invasive ventilation (nCPAP-PS)

1. The HAMILTON-G5 is the preferred equipment for providing non-invasive ventilation, especially for neonates at risk of needing a higher level of support. This is due to increased flexibility and support levels available on the HAMILTON-G5. Non-invasive ventilation is accomplished simply by adding a PS level greater than zero in the nCPAP mode.

2. Settings are based on patient need, generally with initial settings of:

    - PEEP = 6
    - Rate = 15 (the current minimum rate possible on the HAMILTON-G5)
    - PS = 2–3
    - Inspiratory time = 0.35 – 0.4 seconds

    Note that only mandatory breaths are time cycled; patient-triggered breaths are flow cycled based on the ETS (expiratory trigger sensitivity).

3. Exceeding the following parameters indicates potential failure of non-invasive ventilation and support escalation should be considered:

    - Set Respiratory Rate ≥ 30
    - PEEP ≥ 8
    - PS > 4
    - FiO2 > 60%, especially if rising

Conventional ventilation

1. Volume-targeted, pressure-regulated ventilation is optimal to aid in prevention of ventilator-induced lung injury (VILI).

2. The HAMILTON-G5 uses expiratory tidal volume for determination of volume targeting, which tends to be more accurate in the neonatal population with uncuffed endotracheal tubes.

3. APVcmv (Adaptive Pressure Ventilation cmv) is preferred when using volume-targeted ventilation. Compared to APVsimv, APVcmv provides more consistent tidal volumes and more accurate titration of pressures when using volume targeting.

Initial settings

1. Tidal volume target 6 ml/kg initially.

    - Tidal volumes are titrated by 0.5 ml/kg increments as needed to maintain target CO_2 parameters from ABG or end-tidal CO_2.
    - Since tidal volume is a physiologic parameter, weaning is generally not accomplished by turning down tidal volume targets. See "Monitoring during ventilation" for weaning suggestions.
    - Tidal volumes < 4.5 ml/kg result in increased work of breathing.
    - Tidal volumes < 3 ml/kg lead to increased risk of VILI and dead space ventilation.

2. PEEP should be initially set to 6 cmH_20 or per chest x-ray for optimal alveolar recruitment and stabilization.

3. Inspiratory time set to 0.35 – 0.40 seconds or per patient need.

4. Ventilator rate set to 30 breaths per minute initially or per patient need. Initial settings for paralyzed, depressed, or extremely premature babies will generally need to be higher due to lack of spontaneous effort.

Monitoring during ventilation

1. ABG target values (first 7 days of life):

    - pH: 7.25 – 7.45
    - PaO2: 50 – 80 mmHg
    - PaCO2: 45 – 55 mmHg

    Tighter ranges for $PaCO_2$ are achievable with volume-targeted ventilation modes.

2. ABG target values (after 7 days of life):

- pH: 7.20 – 7.40
- PaO_2: 50 – 80 mmHg
- $PaCO_2$: 45 – 65 mmHg

End-tidal CO_2 measurement

1. The HAMILTON-G5 is capable of end-tidal CO_2 measurement in the neonatal population.

2. If using $ETCO_2$, set one of the curves to CO_2 measurement to allow verification of a plateau forming, indicating stabilization of the expiratory flow and greater accuracy of the indicated value.

3. $ETCO_2$ values will need to be compared with ABG data to determine correlation of values and trending.

4. Remember the additional dead space added by the CO_2 sensor.

Ventilation adjustment for out-of-range $PaCO_2$

1. Tidal volumes are titrated by 0.5 ml/kg increments as needed to maintain target CO_2 parameters with the lowest target being 4 ml/kg.

2. Ventilator rate may need to be weaned if total respiratory rate is equal to the set ventilator rate.

3. Required inspiratory pressure to deliver the target tidal volume should be monitored in order to assess patient condition.

    - Maximum working pressure is automatically limited to 10 cmH_20 below the high-pressure alarm setting.
    - Lung disease improvement should result in lower required inspiratory pressure.
    - Deterioration generally manifests as increased pressure requirement.
    - Always keep the overall patient clinical picture in mind when assessing (i.e., a large infant with strong respiratory drive may manifest air hunger by pulling large tidal volumes with resulting automatic pressure weaning).

Endotracheal leak

The HAMILTON-G5 will accurately target tidal volume up to 50% leak. Trigger level is automatically compensated to accommodate leakage flow. Leaks greater than 50% will trigger the Maximum Leak Compensation alarm. If endotracheal leak is consistently > 25%, re-intubation with a larger ET tube should be considered.

- Large leaks will result in decreased effectiveness and accuracy of targeted tidal volume ventilation.
- If the leak is > 25%, the trachea should be large enough to easily accommodate a larger ET tube without being too tight.
- When attempting reintubation, have both the larger ET tube as well as one of the current size available, in case the larger tube does not pass easily.

Weaning volume-targeted ventilation

1. Pressure weaning is an automatic function of this mode. Observation is generally the only requirement.

2. Minimum PS level during volume targeting is 3 cmH_20 above PEEP.

3. Ventilator-set rate may be weaned to assess spontaneous breathing rate and maturity of respiratory control.

4. Total minute ventilation should be followed as well.

Readiness to extubate

1. Mean airway pressure requirement of ≤ 10cmH20 is a good predictor of successful extubation.

2. Evaluation of respiratory rate with decreased ventilator-set rate.

    - Stable respiratory rate with ventilator-set rate weaning is an indication of improving patient status.
    - Increase or decrease in total respiratory rate may indicate less readiness to extubate (representing persistent lung disease or immature respiratory control, respectively).

3. Spontaneous breathing index (SBI): (currently being evaluated for effectiveness)

    - Ratio of spontaneous breaths to ventilator breaths in one minute.
    - Higher ratio of spontaneous breaths indicates higher readiness.

Final remarks

This document was created as part of a larger NICU Respiratory Guidelines document in mid-2012. One of the biggest reasons for this effort was the purchase of HAMILTON-G5 ventilators and the desire to move toward volume-targeted ventilation, which was a concept that most of our staff had not used in clinical practice. I have removed the sections not related to the HAMILTON-G5 in order to focus exclusively on our use of that ventilator.

The initial recommendations were created from a literature search, and have since been adapted and modified based on almost 2 years of actual clinical experience in a busy, 53-bed, Level 3B NICU. All of the refinements we have learned from this experience are incorporated in this document. Currently, volume targeting using the APVcmv mode on the HAMILTON-G5 is used on nearly 100% of our ventilated patients. The only exception is some of our head cooling babies, who are capable of breathing their CO_2 levels down to unacceptable levels despite small tidal volumes due to relatively healthy lungs and profound metabolic acidosis.

Please note that this information represents solely my opinion and not the views and opinions of Hamilton Medical. These guidelines are not meant to replace clinical judgment. If you face unexpected or undesirable results, immediately fall back on your established management practice until the cause for those results can be established. I have prepared this document to provide a framework for sites that are unfamiliar with volume targeting during the clinical trial or initial startup phase with the HAMILTON-G5. I hope this gives you enough information to feel comfortable trialing volume targeting during these phases of operation.

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Feel free to contact me via email (drtoddwest@gmail.com) if you have any questions about these guidelines or my experience with the HAMILTON-G5 in general.

Further reading

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