

Nitric Oxide-Inhaled (iNO): Nursing Management in Newborn Intensive Care Unit (NICU)

Procedure Responsibilities and Authorisation

Department Responsible for Procedure	NICU
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Target Audience	NICU nursing staff
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Procedure Review History

Version	Updated by	Date Updated	Summary of Changes
4	Joyce Mok	Jan 2016	3 yearly review
5	Richard Pagdanganan	Jun 2019	3 yearly review and alternative method for delivery of NO when Inosys is not available
5.1	Richard Pagdanganan	August 2020	Adding a note on colour coding of iNO regulators.
6	Pera Ratana	November 2021	Adding AeroNOx 2.0.

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Nitric Oxide-Inhaled (iNO): Nursing Management in Newborn Intensive Care Unit (NICU)

1 Overview

1.1 Purpose

To safely administer inhaled nitric oxide (iNO) via ventilator or continuous positive airways pressure (CPAP) to infants with increased pulmonary resistance in order to improve systemic arterial oxygenation.

1.2 Scope

Waikato District Health Board (DHB) staff working in NICU.

1.3 Patient group

Neonates and infants in NICU

1.4 Indications

- Primary pulmonary hypertension
- Secondary pulmonary hypertension resulting from:
 - Infection
 - Parenchymal disease such as meconium aspiration syndrome, pneumonia or Respiratory Distress Syndrome (RDS)
 - Pulmonary hypoplasia: idiopathic or secondary to congenital diaphragmatic hernia or anhydramnios/oligohydramnios
 - Severe peripartum hypoxia
 - Congenital lung malformations such as alveolar capillary dysplasia or congenital cystadenomatoid malformation (CCAM)
 - Congenital heart disease

1.5 Special Notes

- **Observe and record hourly the level of nitric oxide (NO) in NO cylinder**, shown on the gauge on regulator attached to the cylinder. Record the gauge readings on a spare line of observation sheet.
- It is the responsibility of the nurse allocated to care for a baby on inhaled Nitric Oxide to monitor NO use and recognise when NO cylinder should be changed.
- Change the NO cylinder when the needle hits the red line and no later than halfway into the red on the regulator. Around 12 hours left of Nitric once needle hits red line. Inspect the circular gas gauge to obtain an accurate reading.
- Inform Nurse Practitioner/Clinical Nurse Specialist/Registrar) as they must be aware and present in the Unit during cylinder change.
- Communicate with the ACNM/co-ordinator so they are aware of the cylinder change.

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1.6 Definitions

AeroNOx 2.0	Portable Nitric Oxide titration and monitoring system
CNS	Clinical Nurse Specialist
CPAP	Continuous positive airways pressure
FiO2	Fraction of Inspired Oxygen
iNO	Inhaled Nitrogen Oxide promotes a fall in pulmonary vascular resistance, leading to an improvement in systemic arterial oxygenation. It is administered in gaseous form through the inspiratory limb of the ventilation circuit and humidifier.
METHAEMOGLOBIN	A dysfunctional form of haemoglobin that is incapable of transporting oxygen, thus reducing blood oxygenation and potentially inducing tissue hypoxemia.
METHAEMOGLOBINEMIA	A blood disorder in which an abnormal amount of methemoglobin is produced.
Nitric Oxide	Nitric Oxide is an endogenous vasodilator that is present in the vascular beds, which plays a major role in regulating muscle tone. In infants it has emerged as a treatment for hypoxemic respiratory failure that is associated with increased pulmonary vascular resistance (PVC).
NNP	Neonatal Nurse Practitioner
PPHN	Persistent Pulmonary Hypertension
PVC	Pulmonary Vascular Resistance

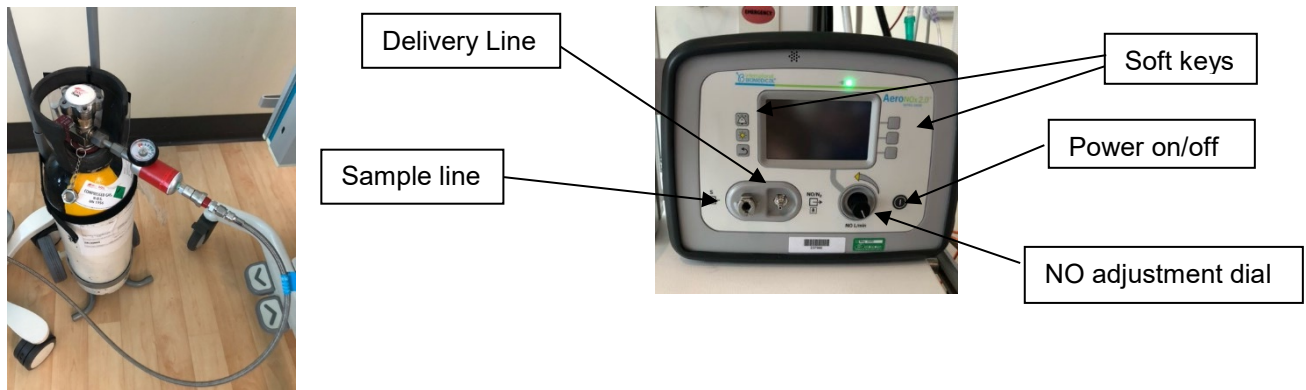
2 Clinical Management

2.1 Competency required

Registered nurse, who has completed L3 ventilation orientation, completed NICU advanced medication NICU3 certification package, and obtained competency.

NB: Pregnant staff have the option to decline caring for patients on iNO, however no official recommendations were found regarding safety during pregnancy. Environmental levels have been found to be at safe levels for pregnant staff working in the same room.

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2.2 Equipment

- AeroNOx 2.0
- AeroNOx 2.0 delivery circuit (spare sets in Technician’s workroom)
- NO cylinder
- AeroNOx set up instructions (in nitric room on AeroNOx 2.0 trolley)

2.3 Procedure

2.3.1 Using AeroNOx

- Refer to AeroNOx set up instructions prepared by technician to assemble equipment to ensure proper and safe administration of iNO.

2.3.2 Using Nitric Oxide flowmeter (if AeroNOx is not available)

- Refer to the manual AeroNOx set up instructions prepared by technician to assemble equipment to ensure proper and safe administration of iNO.
- **If AeroNOx 2.0 is not available in NICU speak to the coordinator and contact ICU as they use the same set up for administrating Nitric.**

2.3.3 Prescribing iNO Treatment

- NNP/CNS/Registrar prescribes iNO because it is a medical responsibility to initiate and manage iNO treatment.
- All changes in iNO administration must be prescribed by NNP/CNS/Registrar and documented on respiratory flow chart.
- For the delivery and weaning of iNO refer to [Nitric Oxide Usage in NICU](#) (1553).

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2.3.4 Monitoring

- Record and document observations:
 - Monitor continuously and document hourly iNO, nitrogen dioxide (NO₂), and iNO flow rate.
 - Effectiveness of iNO, e.g. ↑SpO₂.
 - Monitor and record hourly gauge reading, i.e. level of NO in cylinder, on a spare line of observation sheet.
 - Monitor infant as per NICU service specific nursing and medical procedures: [Care of Ventilated Infants \(0432\)](#); [High frequency oscillation ventilation: Nursing care of infant \(0396\)](#), or [CPAP nursing management: Continuous Positive Airway Pressure \(CPAP\) - Management in NICU \(5285\)](#), and [Nitric oxide usage \(1553\)](#).
- Blood gas analysis
 - Check blood gas after initiation of treatment and PRN to check for effectiveness of treatment. :
 - Check methaemoglobin levels at 1 hour and 12 hours (approx.) after treatment starts to detect if there is any problem with the iNO delivery circuit (e.g. delivering too much iNO) or with the baby (e.g. problems in metabolising methaemoglobin).
 - If methaemoglobinaemia occurs, check the ventilator circuit, particularly the delivery and measuring points of iNO.

2.3.5 Suggestions to maintain safety with nitric oxide cylinder

- Nitric oxide cylinder must be transported, stored and used in an upright position.
- Nitric oxide cylinder to be chained securely to a specially provided trolley during transportation, storage and usage.
- Nitric oxide cylinder to be stored at room temperature.
- No smoking: Nitric oxide is not flammable, but the cylinder may explode in a fire.
- All changes of the cylinder regulator to be carried out by the Technician.
- Recommended that the flow meter is modified to prevent accidental adjustments to flow rates.
- Nitric oxide cylinders to be regularly checked for any leaks.
- Check nitric oxide cylinder compliance/safety label (Certificate of Analysis).

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2.3.6 Suctioning

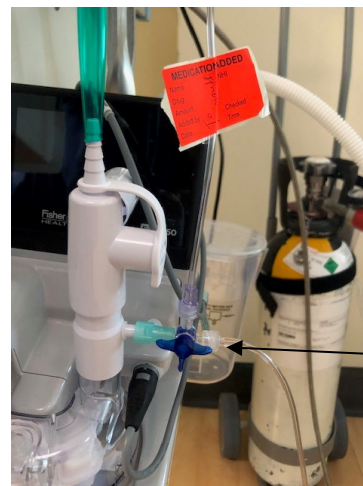
- Use in-line suction to avoid interruption of the circuit.
- Do not change in-line suction while infant receiving iNO therapy.

NOTE: Do not turn off ventilator for procedures such as re-intubation or hand bagging because NO and NO₂ levels may rise in the ventilator tubing when the continuous gas flow is interrupted.

2.3.7 Bagging Circuit

- Ensure bagging circuit with iNO is correctly set up to allow ability to bag baby using O₂ + NO.
- At handover, both the out-going and in-coming nurses must check the bagging circuit together to ensure it is fully working and available for bagging.
- Setting up bagging system according to instructions prepared by technician.

O₂ bagging delivery system



3 way tap to change flow of Nitric Oxide from humidifier to baby to bagging circuit to baby.

2.3.8 Bagging

- When bagging, close the 3 way tap to the ventilator circuit and open the 3 way tap to the bagging circuit to allow iNO to flow into the bagging circuit so baby is bagged with same NO and O₂ concentrations as delivered via ventilator. It is important not to interrupt the nitric flow to the baby so ensure the appropriate position of 3 way tap is open
- Close 3 way tap again from bagging circuit when bagging discontinued and open the 3 way tap to the ventilator circuit, re-establishing iNO circuit via the ventilator.

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2.3.9 Care of the Baby

- Provide care according to NICU nursing and medical procedures for a ventilated baby whether baby is receiving iNO via ventilator or CPAP.
- Ask NNP/CNS/Registrar to be present in NICU (or nearby) when undertaking procedures such as suctioning and other interventions (e.g. turning, changing cylinder, changing respiratory circuits, etc.) because these interventions are extremely risky for these infants, particularly when persistent pulmonary hypertension of the new-born (PPHN) is present.
- Provide support for the baby's parents/family as able because the parents and family/whanau are facing a crisis situation. Many of these babies are born as full term with the expectation that they are healthy, therefore parents and families/whānau are not prepared for their very sick baby.

2.3.10 Change of NO Cylinder

- Ensure replacement cylinder is available so iNO therapy is uninterrupted.
- Refer to instructions prepared by technician.
- Ask NNP/CNS/Registrar to be present in NICU (or nearby) when changing the cylinder.

NOTE: The nitric regulators are colour coded. Red regulators are for the AeroNOx system and also for the transport system. If we have to borrow nitric from ICU please keep their regulators with their delivery units.

2.4 Potential complications

- Methaemoglobinaemia (upper limit 5%)
- NO₂ poisoning – pulmonary oedema, acute respiratory distress syndrome (ARDS)
- Reduced FiO₂ in inspiratory gases
- Interference with platelet function
- Prevent pulmonary vascular bed remodelling (prolonged use in animal experiments).

2.5 After care

Nurses to clean the AeroNOx according to instructions prepared by technician.

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3 Evidence base

3.1 References

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- Pelioswski A. (2012). Inhaled nitric oxide use in newborns. Retrieved from www.ncbi.nlm.nih.gov/pmc/articles/PMC3299357/
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- Royal Children’s Hospital (2015). Inhaled nitric oxide iNO therapy for term and near term neonate. Retrieved from https://www.rch.org.au/neonatal_rch/clinical_practice_guidelines/Inhaled_nitric_oxide_iNO_therapy_for_the_term_or_near_term_neonate/
- Starship child health (2020). Nitric oxide for a child in PICU. Retrieved from : <https://starship.org.nz/guidelines/nitric-oxide-for-a-child-in-picu/>

3.2 Associated Waikato DHB Documents

- NICU Medical Procedure: [Nitric oxide usage](#) (Ref. 1553)
- NICU Nursing Procedure: [Care of Ventilated Infants](#) (Ref. 0432)
- NICU Nursing Procedure: [Continuous Positive Airway Pressure \(CPAP\) - Management in NICU](#) (Ref. 4939)
- NICU Nursing Procedure: [High frequency oscillation ventilation: Nursing care of infant](#) (Ref. 0396)

3.3 Legislative Requirements

- Hazardous Substances (Compressed Gases) Regulations 2004.

3.4 Associated Documents

- Medsafe New Zealand Data sheet Medical Nitrous Oxide

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Appendix A

When AeroNOx is not available here is the manual computation for the delivery of Nitric:

$$\text{iNO flow (ml/min)} = \frac{\text{NO concentration prescribed (ppm)} \times \text{ventilator flow (ml/min)}}{\text{NO concentration in cylinder (ppm)}}$$

When calculating the dose, note the exact concentration on NO cylinder, which will be in the range of 800-1000 parts per million (ppm), this information can be found stamped/written on the cylinder.

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