OXYGEN THERAPY AND DELIVERY DEVICES

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

This guideline aims to address the principles of care and management of the paediatric patient receiving oxygen therapy and/or pulse oximetry monitoring, including the necessary equipment and set processes required.

- The goal of oxygen therapy is to correct or prevent hypoxemia or hypoxia
- It is important to select the appropriate device for oxygen delivery
- Oxygen is a potential hazardous substance
- This document describes standard humidified low flow oxygen therapy delivery
- Oxygen saturation provides an indication of hypoxia
- Pulse Oximetry (SpO_2) is a non-invasive monitoring technique used to estimate the arterial oxygen saturation (S_aO_2 of haemoglobin)
- **In patients receiving supplemental O2, saturations of 100% should be avoided.** In patients nursed in room air, an Sp02 of 100% is acceptable
- **Pulse oximetry alarms are to be set at 92% low and 99% high when a child is receiving oxygen therapy**
- Continuous pulse oximetry monitoring over a defined period of time is the endorsed practice within SCHN. Spot check monitoring is not recommended.
- The value of isolated measurements is limited and trends are more important than absolute figures. Changes in saturation identify deterioration or improvement, caused either by changes in pathology, response to treatment, or both.

Approved by:	SCHN Policy Procedure and Guideline Committee	
Date Effective:	1st October 2019	**Review Period:** 3 years
Team Leader:	CNC Respiratory SCH	**Area/Dept:** Respiratory

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CHANGE SUMMARY

- This guideline replaces the following SCHN documents:
  - SCHN Oxygen therapy and delivery devices
  - Humidified Low Flow Oxygen on the Ward – SCH
  - SCH / CHW Pulse Oximetry
- 5/6/20: Minor review. Amended *Indication for Oxygen Therapy* section.

READ ACKNOWLEDGEMENT

- All clinical staff using oxygen therapy devices and pulse oximetry monitoring are to read and acknowledge they understand the contents of this guideline.

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Purpose and Scope

This guideline aims to address the principles of care and management of the paediatric patient receiving oxygen therapy and/or pulse oximetry monitoring, including the necessary equipment and set processes required.

General Principles

- Supplemental oxygen is the commonest drug prescribed in hospitals [1].
- Supplemental oxygen is provided to correct or prevent hypoxemia and hypoxia which can occur as a result of cardiovascular, metabolic, neurological or respiratory dysfunction [2].
- Supplemental oxygen is generally set to maintain oxygen saturation over 95%, unless an altered calling criterion is documented in BTF chart.
- As oxygen is a drug, it is to be prescribed by a medical officer who determines the device and length of time that it is to be administered [3].
- Humidification is usually not required if patient is on low flow oxygen for the short term. Consideration for humidification should be based on nursing assessment of the individual patient including clinical appearance and length of illness.
- Oxygen saturation monitoring measures the oxygen present in haemoglobin.
- Continuous oxygen saturation monitoring provides a constant indication of oxygenation status. Spot checking oximetry readings have little clinical value; trends over time are preferential for providing information about oxygenation status.
- Oxygen saturation provides an indication of hypoxaemia.
- **In patients receiving supplemental O2, saturations of 100% should be avoided.**
    - Hyperoxia may occur because an Sp02 of 100% may be associated with a very wide range of PaO2 values (*from approximately 100 mmHg to > 600 mmHg, depending on inspired oxygen concentration*).
    - In patients nursed in room air, an Sp02 of 100% is acceptable.

Abbreviations

- SpO_2: when oxygen saturations are measured using a pulse oximeter.
- SaO_2: when arterial oxygen saturation is taken using a blood sample (‘blood gas’).
- The same percentage ranges apply to both the SpO_2 and SaO_2.

Indications for Oxygen Therapy

- Any child in respiratory distress [Tachypnoea, chest wall recession, tracheal tug]
- If indicated post-surgical/anaesthetic procedure
- Hypoxaemia
- Any child hypoventilating and hypoxic
    - All paediatric patients experiencing hypoventilation and/or hypoxia require oxygen administration and urgent review regardless if oxygen saturations improve

Observations of the Patient Receiving Oxygen Therapy

- Record on child's eMR record hourly: [8]
    - Pulse rate
    - Respiratory rate
    - Respiratory effort
    - Oxygen flow rate (or % concentration)
    - Oxygen saturations (continuous pulse oximetry)
    - Capillary refill time
    - Assess and evaluate the child's response to the delivery of oxygen

Clinical Bedside Handover

All oxygen delivery systems (including tubing and gas connection) and medical order are to be checked by TWO staff members and the status documented at EVERY SHIFT change. This includes correct tubing is connected to the correct flow meter (either oxygen or air) and the set flow is correct. The delivery system needs to be checked minimum one hourly.

Possible Complications

- Supplemental oxygen improves oxygenation but does not change ventilation.
- **Administration of supplemental oxygen to patients with certain congenital cardiac lesions** will cause an increase in alveolar oxygen tension and may compromise the balance between pulmonary and systemic blood flow. If unsure please consult the cardiology team.
- **Patients with chronic respiratory obstruction or respiratory insufficiency may develop CO_2 narcosis**. In these patients, the respiratory centre relies on hypoxaemia to maintain adequate ventilation. If they are given oxygen this can reduce their

respiratory drive, causing respiratory depression and a further rise in $PaCO_2$ resulting in narcosis [somnolence, loss of consciousness and then apnoea].

- **Check for contraindications between oxygen therapy and some chemotherapy.**
- **Excess arterial and intra-alveolar oxygen concentrations are toxic in preterm infants and must be avoided by appropriate monitoring and adhering to target range as prescribed by treating physician.**
- To avoid re-breathing if a mask is used, flow rates need to be maintained at 4 L/min; this can be made up of an entire flow of oxygen or a mixture of oxygen and air.
- **In the emergency situation, unprescribed oxygen can be administered immediately.** [4]

Oxygen Delivery Devices - Standard

ALERT: Self inflating resuscitation bags are not to be used as a source of free flow oxygen. They are not designed to be independently attached to a patient's face to deliver oxygen without manual ventilation. [4] Oxygen should be delivered via a mask either Simple face mask or Non-rebreather mask depending on concentration required to maintain SpO_2 levels. Bag valve and mask should certainly be readily available if the patient becomes compromised.

Although the wall oxygen supply is a concentration of 100%, the actual concentration of oxygen the patient receives will vary according to the apparatus used and the flow. A mixture of air and oxygen occurs at different flows depending on the patient's minute volume and whether the child is an oral or nasal breather.

Nasal prongs

Nasal prongs should not be used for children who require more than 30% oxygen. They are used to deliver oxygen directly into the nostrils to a maximum flow rate of 2 litres per minute. If a flow greater than this is used, it is uncomfortable for the child and can cause drying and potential bleeding of the nasal mucosa. [2,5]

Nasal prong oxygen must only be administered by a low flow oxygen regulator. Always ensure that a standard 15l/min regulator is connected at all times to be used in emergency situations.

Nasal prongs are available in sizes neonatal, infant, child and adult. The nasal prong size is selected so the patient can entrain room air and there is NOT a complete seal. The prong size should be approximately half the diameter of the nares. [6] If nasal prongs are to be used continuously, they need to be changed every 3 days

Oxygen flow (Litre/minute)	FiO_2
1	0.24
2	0.28

Simple face mask

The face mask is applied over the mouth and nose. This increases the size of the oxygen reservoir so that a higher flow rate can be administered.

The vent holes in the mask allow room air to be inspired in addition to the oxygen being delivered, and the exhaled carbon dioxide to be released.

A minimum gas flow of 4 L/min must be maintained in order to prevent accumulation of carbon dioxide with subsequent re-breathing [7].

Oxygen flow Litre/minute	FiO_2
4	0.36
5	0.40
6-7	0.50
7-8	0.60

Non re-breathing mask with reservoir bag

The non re-breathing bag is similar to the face mask but with the addition of an oxygen reservoir bag. By increasing the oxygen reservoir, the oxygen concentration can be increased above 60%.

The reservoir bag must remain inflated on inspiration and the oxygen flow rate regulated so that it is sufficient enough to only deflate the bag by ⅓ on inspiration [7].

The non re-breathing bag has one way valves between the reservoir bag and the mask and over the exhalation ports of the mask. These valves prevent the exhaled air from entering the bag and inspiration of room air through the port holes. On inspiration the port holes close and the reservoir valve opens allowing the inspiration of 100% oxygen. On exhalation the port hole valves open and the reservoir valve closes forcing the air out into the atmosphere [7].

It is important the mask fits snugly to allow the inspiration of 100% oxygen.

Oxygen flow Litre/minute	FiO_2
10-15	0.80-1.0

Flow Meters: There are a variety of flow meters available – ranging from 200 mL/minute to 70L/minute. Always check the flow meter is correct for individual patients' oxygen delivery each shift. **Ensure a standard 15L/minute is in situ at the bed space at all times**.

NON CONTACT (ALSO REFERRED TO "WAFTING", OR "BLOW OVER") IS NOT A THERAPEUTIC APPROACH TO OXYGEN DELIVERY.

Humidification

- Administration of oxygen may become necessary to reduce the work of breathing and increase oxygen saturations. Inhalation of oxygen without humidification can dry the mucous membranes causing general discomfort and irritation. By providing optimal humidity with supplemental oxygen, the heat and moisture loss from the mucosa is minimised.
- Humidified oxygen is able to sustain airway patency and lung compliance while maintaining the mucociliary transport system and the consistency of secretions. Humidification also reduces the patient's caloric load required to humidify their inspiratory gases.
- Finally, the fact that the gas flow is warm and moist allows the application of humidified oxygen to be delivered at a high rate.

Consider humidified oxygen

- Neonates: if the gas flow exceeds 500 mL/kg/min
- Infants: with a gas flow of 2 L/min or over
- Children: with a gas flow of 4 L/min or over

Contraindications

- Nasal obstruction e.g. choanal atresia, large polyps
- Life threatening hypoxia secondary to respiratory failure
- Foreign body aspiration
- Numerous persistent apnoeic episodes

Note: Proceed with caution in patients with Congenital Heart Disease.

Care of humidifier

- The circuit including humidification chamber is disposable. The circuit and water bag should be changed every 7 days on the same patient and documented in patient care plan.
- The humidifier, heater wire and temperature probe are not disposable. The probe can be wiped down with Neutral Detergent cleaning solution after use. Do not immerse the heater base or temperature probe electrical connections in any liquid. If the patient has a multi-resistant organism [MRO] then consider using bleach or sending equipment to CSSD for cleaning.

Set-Up and Troubleshooting

For information on humidifier set-up and troubleshooting see Appendix A.

Weaning of Oxygen

- Weaning is to be commenced when child's clinical condition is improving and have observations in the white and blue parameters of Between the Flags.[8]
- Weaning can be gradually attempted by lowering the concentration of oxygen for a fixed period re-evaluating clinical parameters and SpO_2 as required.
- Hourly observations must continue during weaning process.
- Weaning of oxygen is to be documented in patient's medical notes. It is standard practice that a patient may be considered for discharge once they have been off oxygen for 6 hours or more, and have observations in the white and blue parameters of Between the Flags. [8]

Pulse Oximetry

Factors affecting accurate readings of SpO_2

- Poor positioning
- Motion Artefact
- Under Decreased perfusion
- Significant cyanosis (congenital CHD)
- Significant hypothermia
- Anaemia
- Holding or pressing the probe onto the skin too tightly
- Some nail varnish – black, blue, green and frosted
- Bruising under the fingernail
- Synthetic fingernails
- Dirty site
- Carbon monoxide poisoning
- Low battery level/ monitor malfunction
- Probe malfunction or wrong choice of probe
- Excessive light
- Dark skin pigmentation

Equipment

- Oxygen saturation monitor and power cord
- A suitable size sensor probe (note single patient use or reusable)

Procedure

- Explain the procedure to the child (if appropriate for age) and parent/carer.
- Select desired sensor site. If using the digits, assess for warmth and capillary refill
- Add additional elastic cohesive retention bandage to secure- one layer only and ensure not too tight as will reduce blood flow to digit and provide an inaccurate reading. Note that it is not recommended to secure the oxygen saturation probes with Comban ™ stretch compression bandage.

- After turning on, allow 30 seconds for self-testing procedures detection and analysis of waveforms before values are displayed.
- Set appropriate alarm limits to the patient's condition.
- Wait until a constant SpO_2 is displayed, this can take up to 2 minutes

Alarms

- An audible alarm system for determination of oxygen saturation values below a set acceptable limit is necessary as this is important in the overall management of the patient.
- Alarm limits for SpO_2 and heart rate should be set after turning the unit on based on acceptable individual patient values

Normally, low oxygen saturation is set at 92% and high saturation is set at 99% if the child is on oxygen.

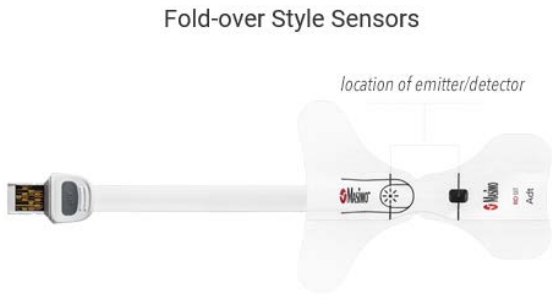
- Please note: Because the Hb-O_2 dissociation curve is sigmoidal, an oxygen saturation of 100% may be associated with a very wide range of PaO_2 values (from approximately 100mmHg to greater than 600mmHg depending on inspired oxygen concentration)

Choice of saturation probe and site

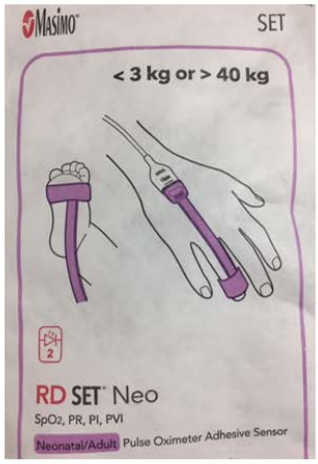
Sensor probes can be disposable or re-usable and there are a variety of probes to select from, depending on what is available within the unit or ward.

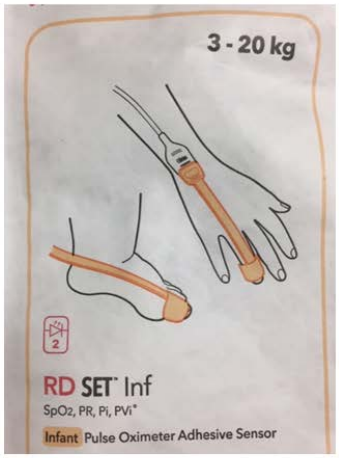
Single Patient Use Probes (disposable)

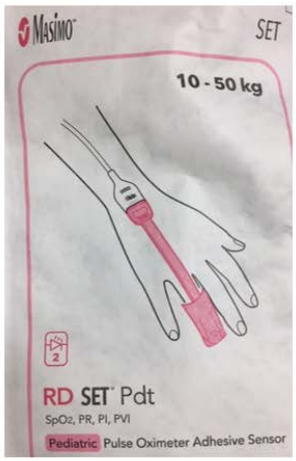
- Single patient use probes should not be used on multiple patients.
- If the patient requires continuous monitoring of oxygen saturation, the single patient use probe is recommended and should remain on the patient for the duration of their admission and discarded on discharge.
    - **At CHW** these probes are a ward stock item however extra can be obtained from Biomedical Engineering.
    - **At SCH** these probes are a ward stock item and can be ordered from Stores.
- When placing a probe the "emitter" should always be placed on the nail unless using on a neonate and wrapping the probe around the foot. The emitter MUST be opposite the detector to ensure accurate saturation reading.



- Choose the appropriate size probe based on the weight of the patient to optimise saturation reading technology.







Reusable Probes

- There are several styles of reusable probes
- Appropriate sizing should be considered as this will .help decrease the incidence of excess ambient light interference.
- "Clip" or "Peg" style sensors are appropriate for fingers (except the thumb) and the earlobe. (However they should be used with caution on the earlobe as may 'pinch')

Choice of saturation site

Younger children	Older children
• Finger • Big toe • Across the palm of the hand (the probe is sited near the base of the little finger) • On the foot (the probe is placed on the outer aspect of the foot, at the base of the little toe) 	• Finger • Big toe 

Note: Use a limb that is not affected by a blood pressure cuff, intravascular infusion line or arterial line, as adequate arterial strength is necessary for obtaining accurate readings. Sites of blood transfusion should also be avoided due to venous engorgement.

Changing of probe site - safety concerns

It has been shown that prolonged application of the probe to one area can cause damage to the skin when using an oxygen saturation probe [9].

Oxygen saturation probes should not cause burns to the skin. However there is greater concern and risk of probes being secured too tightly or left on too long on one site. This potentially can cause necrosis to the skin - in a similar way that a patient receives a pressure sore.

If the child requires continuous monitoring, the probe site and perfusion of the extremity must be checked each hour, and documented on BTF chart.

If continuous monitoring is not required, probes should be removed, to prevent a pressure area forming.

Probe sites must be changed every two hours. [9]

After surgery

Probe sites should be changed at the end of surgery and areas assessed.

Desaturation

- Be aware of changes in saturation. Assess the patient and check the equipment for reasons of desaturation.
- Notify the medical officer if a condition of low SpO_2 occurs and escalate as per CERS. Apply oxygen if required.
- Check medical orders in reference to applying oxygen for desaturations as will be patient specific.
- Document changes

Documentation

As per Observations of the Patient Receiving Oxygen Therapy

- Probe changes should be documented in the patient's clinical notes and recorded on the BTF chart.
- All pressure areas caused by saturation probes must be entered into IIMS.

Related Documents

- Humidified High Flow Nasal Cannula Therapy: http://webapps.schn.health.nsw.gov.au/epolicy/policy/4453
- Nasopharyngeal And Oropharyngeal Suctioning: http://webapps.schn.health.nsw.gov.au/epolicy/policy/4662
- Nasopharyngeal Aspiration (NPA) – SCH: http://webapps.schn.health.nsw.gov.au/epolicy/policy/3500
- Nasopharyngeal Aspiration – CHW: http://webapps.schn.health.nsw.gov.au/epolicy/policy/132

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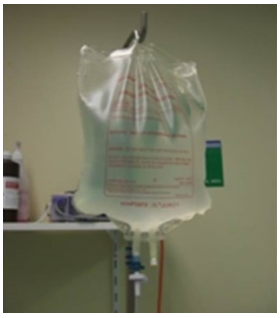
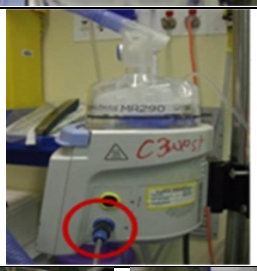
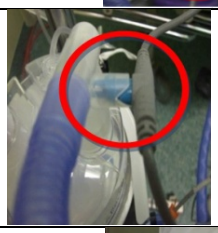
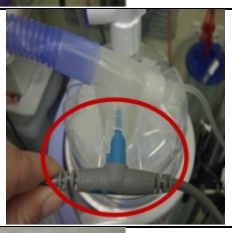
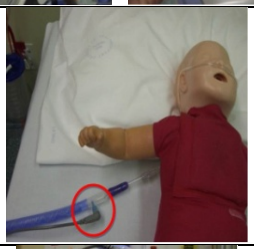
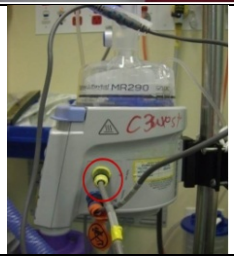
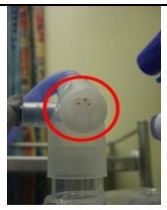
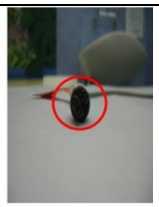
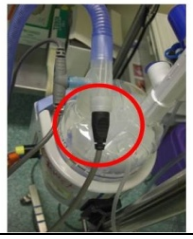
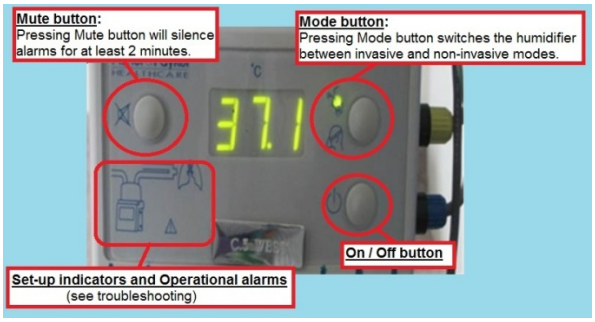
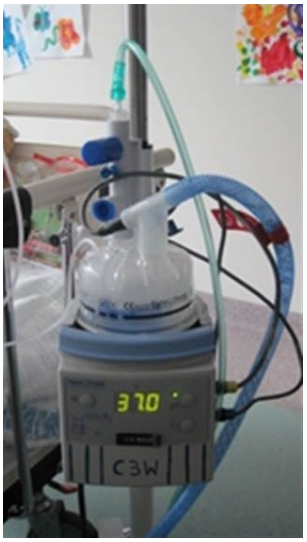
Appendix A: Humidifier Set-Up and Troubleshooting

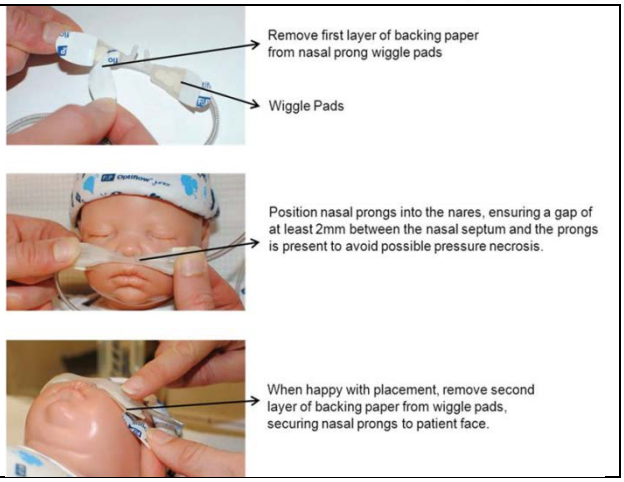
Set-Up

NB: For optimal patient comfort it is recommended that the humidifier be turn on, circuit connected and the gas run for approximately 10-15min in order to warm up the gas to at least 36 degrees, before applying to the patient.

Action	Diagrams
Fit the Chamber **1.** Place the humidified base on to bracket on IV pole. Ensuring that the humidifier is always positioned lower than the patient. **2.** Slide the humidification chamber onto the Humidifier base and remove the blue caps.	
Hang the water bag Hang water bag from IV Pole. Unwind the water feed set (line) and spike water bag. The bag should be at least 50 cm above the chamber. Ensure that water feed set is not kinked and that water is present in chamber.	
Connect the Circuit **3.** Connect the pressure relief value to the chamber.	
4. **Connect** one end of oxygen tubing to O_2 flow meter on wall and the other to the pressure relief value on humidifier.	

5. Set flow meter Flow may be set up to 1 Lmin. Note: if a low flow meter (0-3L) is being used there should always be a standard flow (0-15L) connected to the wall outlet by the bedside.	
6. Connect the elbow of the blue breathing circuit to the humidification chamber.	
Connect the temperature probe **7.** Connect the blue temperature probe plug into the blue socket on the side of the humidifier.	
8. Securely insert blue twin probe into breathing circuit elbow above the chamber.	 
9. Insert blue single probe into port at patient end of breathing circuit.	
Connect the heater wire adaptor **10.** Connect yellow heater wire adaptor plug into yellow socket on the side of	

the humidifier. **11.** Connect clover leaf end into socket on the breathing circuit elbow above the chamber.	  
Turn the humidifier on. a) The humidifier automatically defaults to invasive mode for nasal prongs. **Invasive Mode** Delivers gas as close to body temperature and saturated (37°C) as possible for patients with bypassed airways. Normally the displayed temperature will be 37°, but will automatically adjust (35.5 to 39°C) to compensate for environmental conditions. The humidifier defaults to invasive mode when it is turned on.	
The optimal temperature for humidified oxygen is 37°C. The humidifier heats the circuit to 40°C and there is a drop of 3°C which occurs due to room temperature, gas flow rates and the length of tubing past the thermometer where the temperature is read. The resulting temperature, which should be read off the side of the humidifier is 37°C. NB: Before connecting to the patient ensure that both the temperature probe sensors are correctly and securely fitted. Failure to do so may result in the sensors reading temperature inaccurately and a temperature in excess of 41°C being delivered to the patient.	

Connect to patient. Once circuit is fully assembled and oxygen running, wait approximately 10-15 min before connecting to patient in order to warm up the gas to at least 36 degrees. Connect nasal prongs to end of blue circuit and secure nasal prongs to patient.	

Note: If administering flows ≥ 1L/kg/min refer to: SCHN Humidified High Flow Nasal Cannula Therapy.

Troubleshooting

Excess condensation may develop in the blue circuit tubing and nasal prongs. This may be from inadequate flow (i.e. less than 1 L/min), if this is the case consider changing to standard dry oxygen. Condensation and excess water in tubing can be removed by disconnecting the nasal prongs from blue tubing and pouring water out and reconnecting again.

Set-Up Indicators

Temperature Probe

- Is temperature probe connected to base?
- Temperature probe may be damaged – may need to replace probe.

Chamber Probe

- Is chamber probe fully in*serted into circuit?*
- *Is there* condensation or debris on probe? – may need to be removed and dried.

NOTE: *Temperature probe may be damaged- may need to replace probe*

Airway Probe

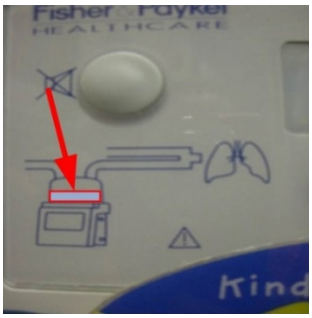
- Is airway probe fully inserted into circuit?
- Is there condensation or debris on probe? - May need to be removed and dried.
- Temperature probe may be damaged- replace

Heater Wire

- Is heater wire adaptor connected to base?
- Is heater wire adaptor connected to circuit?
- Circuit may be damaged- replace.
- Adaptor may be damaged- replace.

Operational Alarms

Water



- Is there water in chamber?
- Is there water in bag?
- Is the feed set kinked?
- Chamber may be damaged- replace.

Humidity

- Humidity alarm present in conjunction with a displayed temperature of 35.5°C or lower
  - Is there a fan?- redirect away from breathing circuit
  - Is there a draft?- redirect away from breathing circuit
  - Sometimes due to condensation on temperature probe. Take out briefly and dry. Replace and issue may be resolved.
- Humidity alarm present in conjunction with a displayed temperature of 41°C of higher
  - Monitor displayed temperature closely
  - Sometimes due to condensation on temperature probe. Take out briefly and dry. Replace and issue may be resolved.
  - Temperature probe may be damaged- replace.