Title:	***Standard Operating Procedure (SOP): Domiciliary Non-Invasive Ventilation (NIV) Set-up***
Area:	Acute Respiratory Unit/Respiratory clinic NIV service, RSCH
Date Approved:	10th March 2023
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Purpose of the SOP:	To provide a unified standard of care for adult patients to be set up on home non-invasive ventilation (NIV).
Scope:	The procedure must be followed by all healthcare professionals involved with Home NIV therapy.
Considerations for home NIV: **Signs and symptoms of hypercapnic respiratory failure**	• Morning headache –increase in carbon dioxide will cause cerebral vasodilatation and therefore headache. This tends to wear off as the day progresses because tidal volume increases as the patient wakes and becomes active, which will help eliminating CO_2 (morning headaches may also be caused by hypoxia only). • Day time somnolence, confusion and peripheral oedema.

Indications for domiciliary NIV:	• COPD: if below parameters persist with maximal optimised medical therapy (bronchodilators, +/-home oxygen therapy-if applicable)
	  ○ pCO_2 >6.5Kpa
	  ○ RR > 22bpm
	  ○ Symptomatic: somnolence, morning headaches, confusion
	
	• Chest wall disorders: symptomatic chronic respiratory failure with evidence of nocturnal and/or daytime hypoventilation.
	  ○ pCO_2 <6.5Kpa and >6Kpa
	  ○ Breathlessness
	  ○ VC < 1L
	
	• Obesity hypoventilation syndrome/sleep disordered breathing
	  ○ pCO_2 >6.5Kpa
	  ○ RR > 22bpm
	  ○ Symptomatic: somnolence, morning headaches, confusion

Contraindications to domiciliary NIV:	<u>Absolute Contraindications</u> • Acute hypercapnic respiratory failure or cardiac/respiratory arrest: this will require acute response and continuous monitoring. • Impaired consciousness with Glasgow Coma Scale (GCS) <8 and/or inability to protect own airway • Facial trauma • Un-drained pneumothorax • Severe agitation/confusion • Fixed upper airway obstruction <u>Relative Contraindications</u> • Recent facial/upper airway or upper gastrointestinal tract surgery • Bowel obstruction • Copious respiratory secretions **Note: Always take into consideration patient's wishes. It is important to clearly explain to the patient the impact that NIV will have on symptoms and quality of life in general.**
Ventilation modes:	• Spontaneous (S): this mode allows the patient to trigger and cycle breaths • Timed (T): this mode is triggered and cycled by the device • Spontaneous Timed (ST mode): the patient triggers and cycles each breath, but there is a backup respiratory rate if needed. • Average volume assured pressure support (AVAPS): The patient triggers the breath but the ventilator cycles this to achieve a set volume. It also adjusts the pressure (IPAP) in order to reach the volume. It needs a min and max IPAP setting, a volume setting and an EPAP. • aPCV (assisted pressure controlled ventilation): mostly used for neuromuscular conditions. It gives a set pressure but allows the patient to take own breaths.
Procedure for setting up home NIV:	• Review medical history and notes to clarify indication for NIV • Check that required investigations are done: ABG, spirometry +/-respiratory muscle testing, CXR/CT, echocardiogram, overnight pulse oximetry. • Check the notes for the request of domiciliary NIV set-up. • It is recommended a baseline Capillary Blood Gas is performed prior to commencing treatment. See SOP-Capillary Blood Gas for further guidance. Assess the Capillary blood gas results. • Ensure you are wearing the correct Personal Protective Equipment (PPE) for the procedure: Water-resistant apron, surgical face mask and gloves, as per trust guidelines in clinical areas.

Patient Preparation:	Provide the patient with an appropriate explanation and reassurance throughout set up. <u>Points to explain:</u> 1. Why are they having NIV? The reason they are having NIV is that there is under breathing/ventilation at night and as a result there is a build-up of carbon dioxide, in the blood overnight. This causes morning headaches, lethargy, a "thick-headed" feeling, daytime somnolence, and even confusion. During sleep, muscles relax and as a result breathing achieves much lower volumes at night compared to during the day. This can cause a reduction in how much carbon dioxide is exhaled. 2. Why is a build-up of carbon dioxide a bad thing? The build-up of carbon dioxide can worsen over time and it can spell the start of a spiral downwards of worsening breathing both during the day and night. When corrected at night, we can halt or slow-down that worsening ventilation process. 3. How does NIV work? NIV increases the volume of inhaled and exhaled air, therefore creating a higher chance of excreting carbon dioxide. NIV assists to take slightly bigger breaths by pushing air into the lungs when taking a breath. The NIV is attached to a mask via a piece of tubing. The mask is worn over nose and mouth or under the nose and mount. Sometimes, nasal masks (only covering the nose) can be used, but they are not first line in NIV. NIV provides two levels of pressure: • Lower level of pressure on exhalation (EPAP) to splint open the upper and small airways and to flush out the waste gas (CO_2) • A higher level of pressure (IPAP) to assist inspiration to achieve a fuller breath 4. How are NIV settings decided? The modes of ventilation (explained in section below, "**Initiation of NIV**") will be adjusted according to the patient's condition. In non-complex domiciliary NIV the most common mode is ST which allows spontaneous breathing with some back up from the ventilator when needed. The settings are adjusted according to: • The patient's medical condition causing hypercapnia. • The levels of CO_2. This can be measured using capillary or arterial blood (see SOP for CBG) or transcutaneous capnography (TOSCA/TCM5 device – see SOP for transcutaneous capnography). Once NIV is established, management will include: • Regular face to face or remote reviews • Performance of CBGs, and/or TOSCA monitoring to titrate settings if needed.

Initiation of NIV: **General initially settings to commence NIV** **(for specific medical conditions see table below)**	Spontaneous timed (ST) • This allows patient to trigger breaths but back up respiratory rate will ensure timed breaths if patient has central apnoeas, or the ventilator is unable to register that the patient is attempting to take a breath. **Initial minimum parameters during set-up: these will need to be up-titrated as needed** IPAP = 10 cmH_2O, titrated rapidly in 2-5 cm increments at a rate of approximately 5cmH2O each 5-10 minutes with a usual pressure target of 20cm H_2O or until a therapeutic response is achieved or patient tolerability has been reached. EPAP = 4-5 cmH_2O (Expiratory pressure (cannot go below 4cmH_2O. EPAP>10cmH_20 needs discussion with consultant) RR = 12 breaths per minute (usually to be set 2 breaths below the patient's resting RR. However, it should not be lower than 10) Ti_{max} = 2.0 seconds (maximum inspiratory time NIV will allow) Ti_{min} = 0.3 seconds (minimum inspiratory time NIV will allow) Rise Time = 100 – 150ms for obstructive patients, e.g. COPD patients = 200 – 300ms for restrictive patient, e.g. OHS or scoliosis Patients Trigger sensitivity (for Resmed ventilators, not available on Phillips DreamStation ST, but available in Trilogy EVO – for acute NIV): • For resmed ventilator ○ Low: requires a higher change in flow to trigger IPAP ○ Medium: requires medium level of flow change to trigger IPAP ○ High: very sensitive, will trigger IPAP with small changes in flow • For Phillips Trilogy EVO: (not currently used for home NIV) ○ Autotrack: ventilator monitors when it should be trigger and adjusts to it ○ Flow trigger sensitivity: from 0.5 to 9 L/m. 0.5L/m will be more sensitive and 9L/m less sensitive. Go through the set-up of the device with the patient including comfort settings (Ramp; humidity), changing filters and remote monitoring via the remote monitoring platform. Ensure the patient understands remote monitoring and signs the consent form prior to setting up the patient account on remote monitoring platform. • Measure the patient for the most appropriate mask (nasal/full face) • Gently let the patient try the mask without ventilator therapy attached (they may feel claustrophobic due to lack of flow through it) • Go through mask fit and switch the device on • Tell the patient that the machine will not "take over" their breathing, and that the machine should be following their breathing pattern not the other

	way around. However, there is a back-up respiratory rate that will ensure that a set rate is maintained should the patient's rate declined. • Gradually titrate the IPAP pressure upwards by 1-2 cmH_2O at a time giving them a few minutes at each pressure to get used to it. If patient becomes uncomfortable with the IPAP, reduce it back 1 – 2 cmH_2O until they are comfortable and feel they could fall asleep on that pressure (don't go below 10cmH_2O on IPAP). Most patients who have never used NIV before won't tolerate more than 14/6. • It's useful to tell the patient that they can take long or short breaths and they just have to stop breathing in and the NIV will stop pushing the breath. • If the patient is on oxygen initially entrain the same amount through the mask/tubing. Aim to reduce the entrained oxygen until SaO_2 > 90% (although for some 85% may be appropriate, this will need to be discussed with the consultant). • If the $PaCO_2$ increases or remains the same then the pressure should be increased. (Also check to see if the oxygen can be decreased, some patients are very oxygen sensitive.) If the PaO_2 is low but the $PaCO_2$ is decreasing or normal, more oxygen will need to be entrained.
Questions to evaluate what settings to change to achieve comfort:	It is important to give the patient time to think about their breathing in order to answer the questions. It is best to ask questions which require only a yes or no answer so that they do not need to stop the therapy to answer. Adjusting Trigger 1. When you take a breath does the machine push the extra bit of air in straight away? • If yes, leave the trigger setting as it is. • If no, then…. 2. Is there a delay between trying to take a breath and the machine pushing the extra bit of air? • If yes, change the trigger to high • If no, then…. 3. Does the breath come before you attempt to take the breath? • If yes, decrease respiratory rate. • If no, then return to step 1. 4. If in doubt get the patient to try all three trigger settings and decide which one feels more comfortable.

Adjusting Cycle

1. Ask patient if, when they want to breathe out, the machine is letting them breathe out easily. In other words, is it dropping the pressure from the high pressure to the low pressure just before they are ready to breathe out.
    - If yes, leave Cycle setting as is.
    - If no, then….

2. Do they have to actively push the breath out?
    - If yes, change cycle to high
    - If no, then return to step 1

3. If in doubt get the patient to try all three cycle settings and decide which one feels more comfortable.

NB: COPD patients are usually more comfortable with a high cycle

Adjusting IPAP

1. Ask the patient if they feel like they are getting a big enough breath? In other words, do they feel their lungs are full enough with each breath?
    - If yes, leave IPAP setting
    - If no, increase IPAP setting
2. Does the patient feel like the breaths are too big or their lungs are too full?
    - If yes, decrease IPAP
    - If no, leave IPAP setting

Adjusting Respiratory Rate (RR)

1. Ask the patient to stop breathing themselves and wait for the machine to force them to take a timed breath.
2. Did the timed breath come at around about the time they wanted to take a breath?
    - If yes, leave RR setting as is.
    - If no, then…
3. Were they desperate for a breath by the time the breath came?
    - If yes, then increase RR.
    - If no, then….
4. Is the machine making them take a breath before they are ready?
    - If yes, then decrease the RR.
    - If no, go back to step 1.

NB: When patients describe not being able to keep up with the machine that is usually because the RR is too high.

Documentation and follow up:	Ensure appropriate documentation and follow up appointments are in place. • Device settings, mask and others, recorded on Bamboo data forms, under Respiratory medicine. • Remote monitoring platform • Consumables • Appropriate follow up appointments are in place (see Follow up pathway for more information)	
Identifying problems / making adjustments:	1. Problem: No initial fall in $PaCO_2$ Adjustments Mask fit Insufficient pressure : Increase IPAP Intermittent triggering : consider increase EPAP 2. Problem: hypoxic Adjustments: Add O2 (If indicated by Consultant) Consider increase EPAP if interstitial changes on CXR or OSA. Make sure target saturations are in place. 3. Problem : No further fall PCO_2 Adjustments: Check leak & exhalation valve OK Increase IPAP (rarely need > 25) Consider switch to pressure control (Set Ti) Repeat CBG/ABG and monitor HCO_3^- and pH. 4. Problem: Unresolved obstructive apnoea Adjustment Ti min (to 1.0s) and reduce cycle to "Low" 5. Problem Bloating NIV can cause abdominal dilatation from too much air being "swallowed". Adjustment Increase Rise time	Rationale Leak will impair triggering This will increase tidal volume External PEEP, by offsetting PEEPi (intrinsic PEEP – gas trapping), will make triggering easier. To increase FiO2 Recruit lung units not ventilated or stent open upper airway (heavy snoring) To ensure no rebreathing To increase Vt To provide timed mode ventilation if PS inadequate Leak makes trigger difficult pCO_2 maybe compensating a metabolic alkalosis which will need further investigations. To sustain inspiration for longer and help maintain airway. This will allow for a more slow and progressive inhalation.

	Rise time: Obstructive patients: 100-150ms Restrictive patients: 200-350ms	
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Appendix 1

NIV protocols: start up settings according to medical condition.

NIV Set Up		
Disease		
COPD	Restrictive chest wall/OHS	COPD+OSA
Settings	Settings	Settings
IPAP : 10-15 cmH_2O	IPAP : 15-20 cmH_2O	IPAP : 15-20 cmH_2O
EPAP: 4-5 cmH_2O	EPAP: 6-8 cmH_2O	EPAP: 6-8 cmH_2O
Rise time: 100-150	Rise time: 200-350	Rise time: 150-300
Ti min: 0.8	Ti min: 1.2	Ti min: 0.8
Ti max: 1.2	Ti max: 2.0	Ti max: 2.0
Trigger: Medium	Trigger: Medium	Trigger: Medium
Cycle: Medium	Cycle: Medium	Cycle: Medium
BR: 12 bpm	BR: 15 bpm	BR:12 bpm
I:E: 1:2 to 1:3	I:E: 1:1	I:E: 1:1
Possible need for EPAP>8 Severe OHS (BMI>35), Lung recruitment: eg hypoxia in severe Kyphoscolios, oppose intrinsic PEEP in severe airflow obstruction or to maintain adequate PS when high EPAP required Pulmonary Hypertension: Try to keep the pressures as low as possible		
Notes: Restrictive patients need more PS support (>10cmH_2O)		

Appendix 2: Flow and cycle settings graphs (Resmed Lumis 150 ventilators)

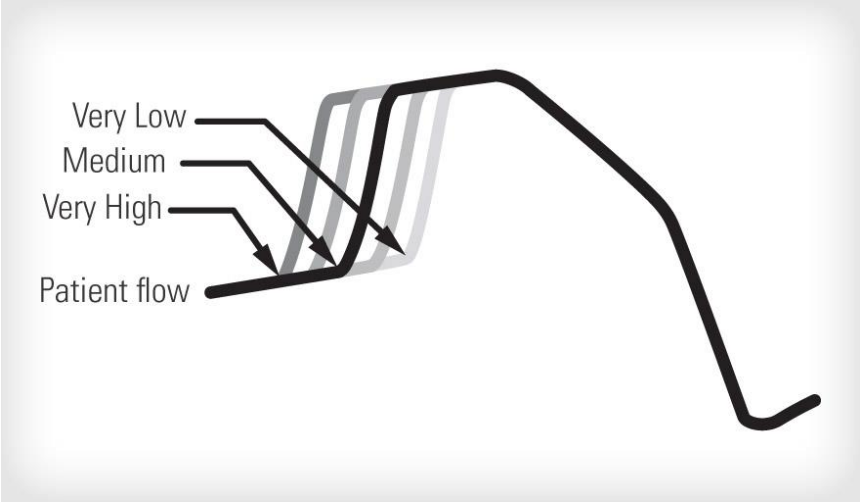

Figure 1: Flow trigger

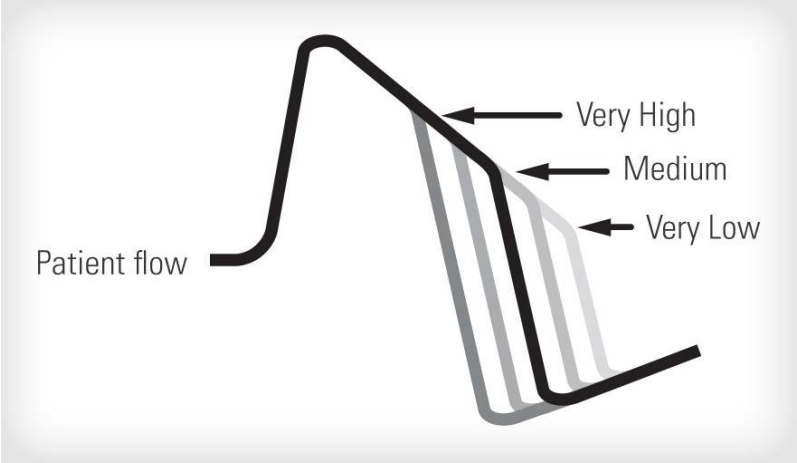

Figure 2: Breath cycle

Appendix 3

TERM	DEFINITION
CPAP	Continuous Positive Airway Pressure. This is not a ventilation mode but may be used to treat Obstructive Sleep Apnoea (OSA) with a CPAP machine or to treat hypoxaemia using high flow oxygen.
T (timed) mode	The cycling between IPAP/EPAP is machine triggered only. It is set at a specific rate.
S (spontaneous) mode	The ventilator delivers the IPAP when the flow sensor detects a spontaneous effort. It cycles back to EPAP at the end of inspiration. There is no set up respiratory rate.
S/T mode	The ventilator detects patient effort and delivers IPAP, however, there is a back-up rate which ensures that the patient still receives a set number of breaths.
Pressure Support (PSV)	This mode of ventilation means the length of inspiratory time is dictated by the patient unless the back-up rate falls and the ventilator will give a set inspiratory time (Ti) as a timed breath.
Pressure Control (PCV)	This mode of ventilation means the length of inspiration is controlled by the ventilator whether the breath delivered to the patient is triggered or timed. The patient is only able to breath spontaneously between mechanical breaths.
BiPAP	A generic term for a ventilator which sets an inspiratory and expiratory pressure.
IPAP	Inspiratory Positive Airway Pressure is the pressure set on the ventilator during the inspiratory phase, used to control carbon dioxide levels and improve gas exchange.
EPAP	Expiratory Positive Airway Pressure is the pressure set on the ventilator during the exhalation phase, used to keep the airways patent and also to improve oxygenation.
PEEP	Positive End Expiratory Pressure donates an airway pressure that is kept above atmospheric pressure at the end of the exhalation phase. This may improve gas exchange and may also recruit alveoli.
Tidal Volume (TV)	In NIV terms it is the volume delivered by the ventilator on inspiration, these values are only a guide and should not be deemed accurate, always look for good chest wall movement to decide whether the pressure or volume is set high enough.
Inspiratory Time (Ti)	The time the ventilator takes to deliver the set pressure on inspiration, in PCV mode this is dictated by the ventilator and in PSV it is dictated by the patient unless it is a timed breath.
Type I respiratory failure	Reduced oxygen levels (PaO_2 ‹ 8kPa) with normal or low carbon dioxide levels.
Type II respiratory failure	Reduced oxygen levels with increased carbon dioxide levels ($PaCO_2$ › 6.5 kPa)

References and further reading:

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