The Faculty of Intensive Care Medicine

Breathing Circuits

A resource for designing local guidance

February 2025

STOP!

This is not a clinical guidance document.

This document is a resource for local safety, quality improvement and other relevant staff to design their own local guidance for breathing circuits

Foreword

As part of the safety component of the Faculty of Intensive Care Medicine's Professional Affairs and Safety Committee (FICMPAS), we aim to create national resources on key topics.

The resources in this document were developed following recurrent safety incidents concerned with the connection and reconnection of both invasive and non-invasive breathing circuits. Many of these incidents have been shared in the Safety Bulletin.

Recurrent themes reported from Patient Safety Incidents brought to FICMPAS's attention include:

- Incorrect assembly of equipment, including *lack of exhalation route.*
- Failure to take the ventilator out of standby.
- Lack of oxygen/air flow reaching the patient due to disconnection, leaks in the circuit or lack of supply.
- Lack of monitoring, especially fully working capnography.
- Obstruction of the circuit/system due to blocked filters, confusion between bacterial filters and HME filters, blockage/displacement of endotracheal and tracheostomy tubes.
- Inappropriate/inaudible alarm settings or monitoring or unrecognised alarms.
- Lack of visibility/observation of patients.

FICMPAS created this document to act a resource to help in the designing of local guidance and visual aids for the connection and reconnection of breathing circuits. Since local circumstances matter, we hope that this document should prove easily adaptable for use by individual intensive care quality or governance leads, or those with an equivalent role for improving safety and quality of patient care.

The resource is divided between invasive and non-invasive breathing circuits. For each breathing circuit we include a few pages of text which might be lifted either verbatim or modified as appropriate, into local breathing circuit guidelines. The text covers such key areas as summarising the most likely safety incidents to be aware of and providing bullet point considerations for pre, during and post breathing circuit connection and reconnection.

Additionally, for each breathing circuit we have created a visual aid made up of a flow chart and a labelled image of a connected breathing circuit. FICMPAS's view is that readily accessible visual aids for use by intensive care staff at the patient's bedside, during any connection and reconnection of a breathing circuit, will have the most impact on improving patient safety in this area of practice. We

would therefore encourage the use of a visual aid check list before every patient connection and reconnection to a breathing circuit.

Given the variety of breathing circuits in use, there is no intention that our labelled image, as provided in this resource, be the one that is used locally. Instead we provide the visual aids as a template example for local adaption and implementation. We encourage local units to take our visual aid example and use it as a guide for creating their own local breathing circuit visual check list. This would include taking and labelling photographs of any locally used breathing circuit. Other areas with delivery non-invasive ventilation, for example, Respiratory Support Units or other appropriate wards, may wish to use this work as a template for creating their own local guidance.

If this endeavour would be aided by the ability to modify the Microsoft Word and Powerpoint originals used in this resource, please email contact@ficm.ac.uk and these can be provided.

In no way does this resource replace local guidance or training in the application and use of breathing circuits. While some areas outside of intensive care, who also use breathing circuits, may wish to adapt our resource, this needs to be done with care as we have written it specifically with an intensive care audience in mind.

Finally FICMPAS would like to thank Prof Gary Mills for leading on the development of this resource.

We would welcome any feedback on this resource and how it might be enhanced. Please send feedback to FICMPAS via **contact@ficm.ac.uk**

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Dr Peter Hersey **FICM Safety Lead**

Adult ICU Ventilator Circuit Guidance

"The patient, the machine and everything in between."

Check there is flow in and out.

Ensure the patient can exhale.

Ensure the machine and oxygen supply is on and ventilating the patient.

Recurrent incidents

Incidents related to breathing circuits, respiratory support and oxygenation are frequently reported in Patient Safety Incidents. Theses identified include:

- Incorrect assembly of equipment, including **lack of exhalation route**.
- Failure to take the ventilator out of standby.
- Failure to fully connect the oxygen.
- Lack of monitoring, especially fully working capnography.
- Inadequate preparation for intubation and subsequent ventilation.
- Obstruction of the circuit/system due to blocked filters, confusion between bacterial filters and HME filters, blockage/displacement of endotracheal and tracheostomy tubes.
- Failure to top up humidification fluid.
- Inaudible or unrecognised alarms.

Different equipment may be available in different organisations and departments. To reduce the risk associated with these variables, each unit should have a training programme and guidance **which includes colour photographs and/or exploded colour diagrams of locally agreed breathing circuit configurations, taking into consideration local specialty and procurement preferences. These should be used before and during ventilation**. Guidance should also be available that describes the preferred ventilatory modes for the maintenance of ventilation in the acute phase, and for weaning.

Changes to the guidance, checklists or pictures (for operational or equipment availability reasons) should be made by an approved and designated author within each department. Examples are attached, but each unit should produce its own, tailored to its requirements and equipment.

During assembly of the breathing circuit the locally prepared exploded coloured diagram or coloured photograph should be used to:

- Check an oxygen supply is available and functioning.
- Check there is a patent route from the inspiratory gas flow side, all the way though to expiration. Flow through the system should be tested, including the expiratory route **before** connection to the patient.
- A labelled diagram and colour photograph of the preferred unit set up of the ventilator, including all tubing and humidification, through to the connection with the endotracheal tube or tracheostomy, should be immediately available.

Humidification

- HME filters and bacterial/viral filters are not the same. **DO NOT CONFUSE THEM**.
- If used, positioning and type should be clear. Change dates should be marked.
- With Active Heater Humidification systems:
    - **DO NOT USE AN HME or HMEF WITH AN ACTIVE HEATER/HUMIDIFICATION SYSTEM.**
    - Humidifier connections including tube connections from the inspiratory outlet of the ventilator and onward to the Y piece should be checked and confirmed.
    - Temperature monitoring and electrical connections should be confirmed.
    - Active Humidifier water and connections should be confirmed.

Bacterial/viral filter (more than one in the circuit may be appropriate)

- May be placed on the ventilator end of the inspiratory limb to protect the patient.
- May be placed on the ventilator end of the expiratory limb to protect the ventilator and the staff in the room.
- Alternatively, may be placed between the Y and the catheter mount to the patient, when an HME is NOT in use.

Before use

- The ventilator should be plugged in (and charged where available).
- A self-inflating bag and mask should be immediately available and difficult intubation equipment rapidly available.
- Oxygen (and air where appropriate) connected and the connections confirmed.
- Suitable type and length of closed/integrated suction and related catheter mount or appropriate alternative selected.

Alarms and monitoring

- Check alarm parameters are set appropriately and back up modes have suitable settings.
- Check alarm volumes are audible.
- External alarms – set suitable max and min limits- may include FiO2, SpO2, ETCO2, ECG, Respiratory rate, BP/NIBP.
- Ensure capnography is connected and functioning.
- Ensure standard monitoring is in place and attached (SpO2, ECG, IBP/NIBP) and consider additional monitoring including BIS, Tof4 when neuromuscular blocking infusions in use.

During use

- **ENSURE VENTILATOR IS SWITCHED ON and OUT OF STANDBY MODE.**
- Ensure FiO2 and appropriate ventilator settings have been selected.
- **OBSERVE PATIENT AND CHEST MOVEMENTS TO ENSURE PATIENT IS VENTILATING NORMALLY.**
- Check flow, volume, pressure and capnography traces to ensure satisfactory inspiration and **EXPIRATION.**
- Ensure the endotracheal tube/tracheostomy tube is tied/fastened and supported appropriately.
- Ensure the length and size of the tube is noted, INCLUDING LENGTH AT LIPS: is the endotracheal tube at the correct depth in the trachea?
- Consider the monitoring/maintenance of endotracheal/tracheostomy cuff pressure.
- Ensure subglottic suction is appropriately connected when in use.
- If respiratory deterioration occurs, reconsider position of nasogastric (NG) tube or NG complication such as aspiration or pneumothorax following misplacement.
- Check suitable sedation is being administered.
- If ventilatory pressures are rising or tidal volumes falling consider "patient, machine (ventilator) and everything in between".
- Report incidents or near misses.

If the patient is disconnected and reconnected to the ventilator

- Check the ventilator is back on and out of standby mode.
  STOP MOMENT
- Check chest movement (Inspiration and **EXPIRATION**), monitors including flow and capnography traces, volumes, pressures and saturations.
- Recheck alarm settings.

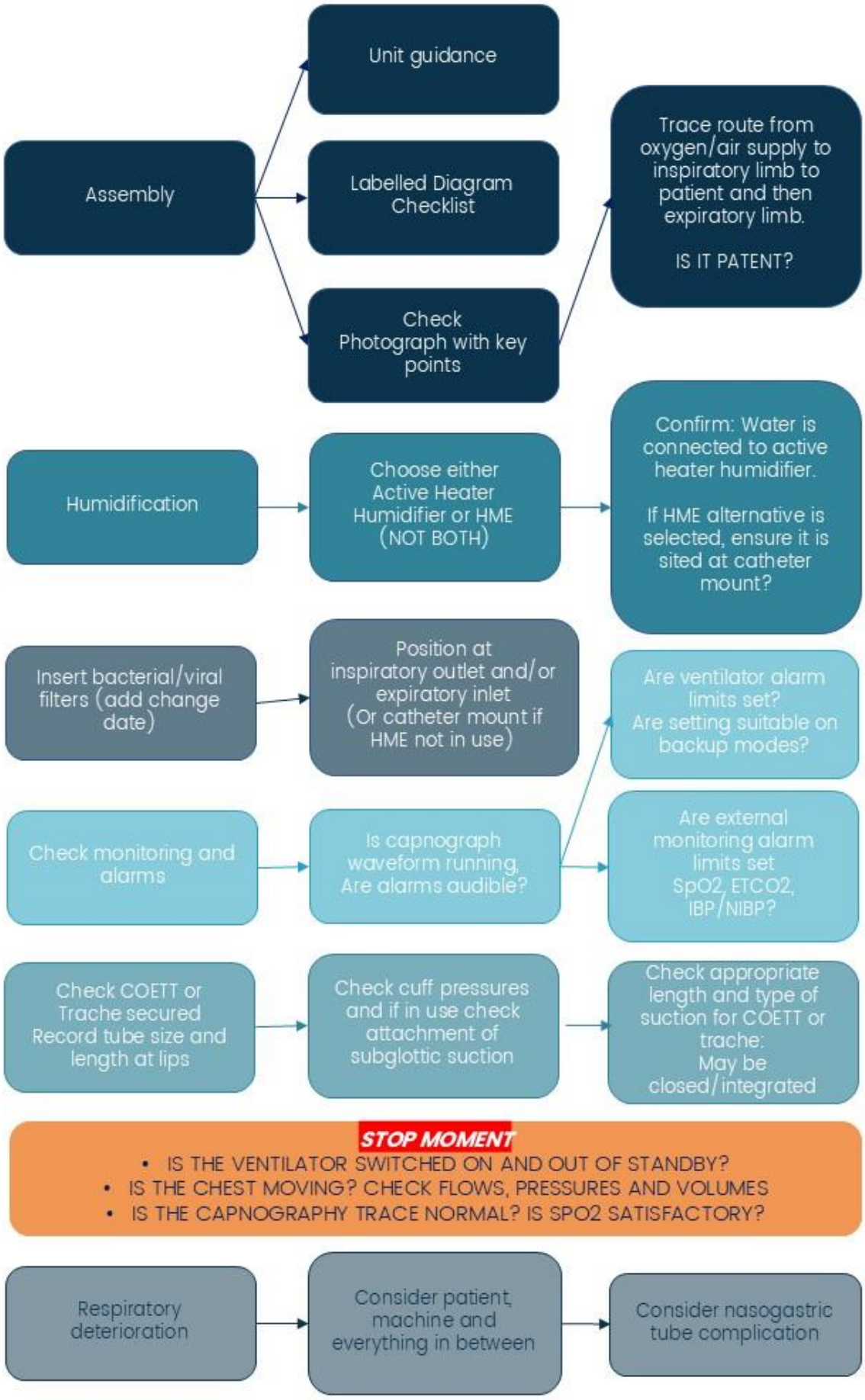
Nebulising medications

- Use an agreed standard operating procedure for nebulisers.
- Position the nebuliser on the inspiratory limb of the ventilator circuit or in a position recommended by the manufacturer.
- Ensure inspiration and expiration can occur.
- Remove the HME filter during nebulisation if in use (if practical and/or safe to do so).
- Change the HME filter after each administration of nebulised therapy (if practical and/or safe to do so).
- Monitor the patient closely during and after nebulisation.

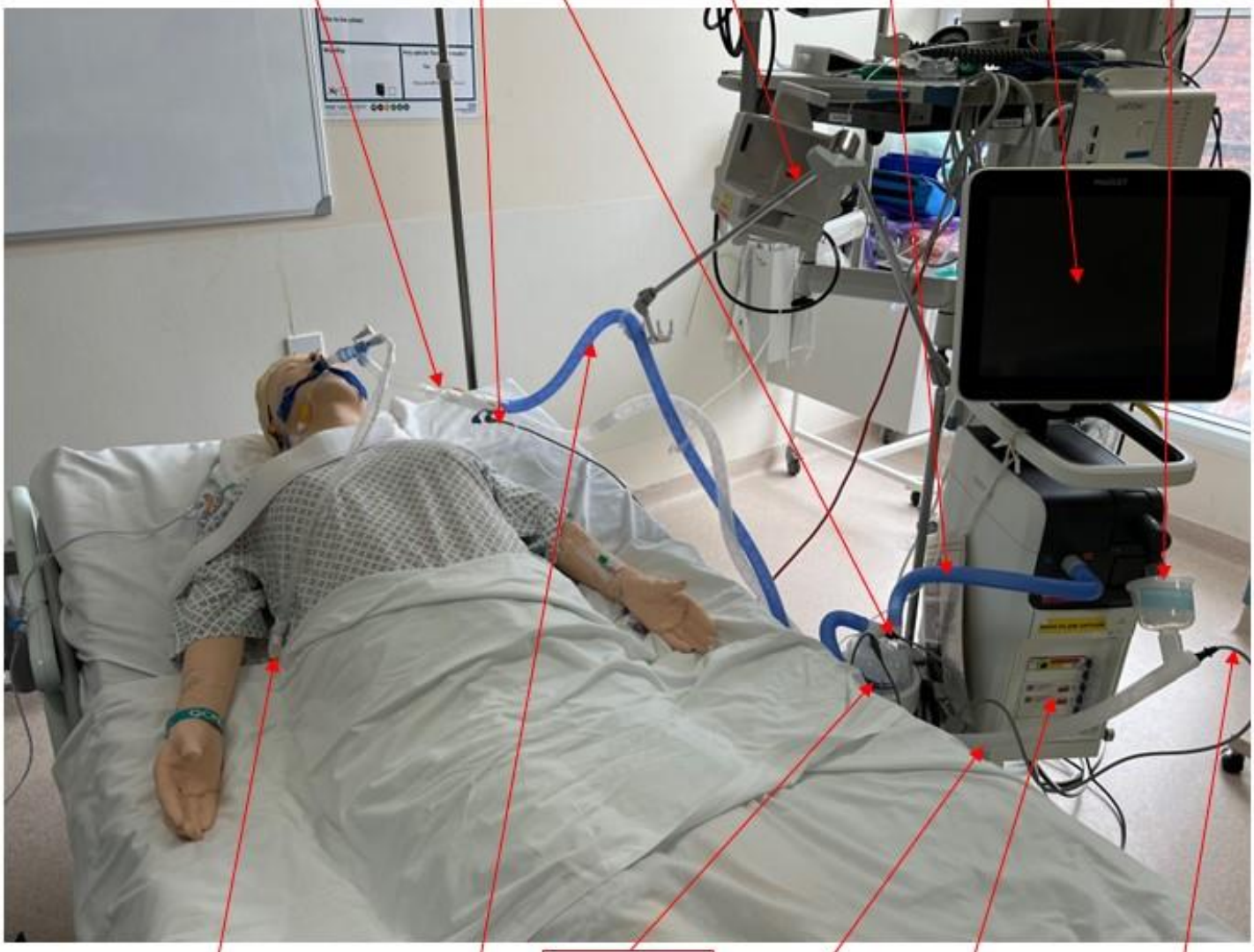
Infection Control

- Change all filters/tubes/equipment in line with manufacturer's recommendations.

Adult ICU Ventilator Circuit Guidance



Local ventilator set up picture/s example



Compare equipment to your local set up picture/s and tick off points after checking

This is an example template that would need customising for local equipment

Adult ICU Non-Invasive Ventilation Circuit Guidance (CPAP/NIV)

"The patient, the machine and everything in between."

Check there is flow in and out. Ensure the patient can exhale.

Recurrent incidents

Incidents related to breathing circuits, respiratory support and oxygenation are frequently reported. Themes identified from reported Patient Safety Incidents include[1,2,3]:

- Incorrect assembly of equipment, including **lack of exhalation route.**
- Lack of visibility/observation of patients.
- Inappropriate/inaudible alarm settings or monitoring.
- Lack of oxygen/air flow due to disconnection or lack of supply.
- Leaks in the circuit resulting in inadequate flow reaching the patient.
- Obstruction of the circuit/system due to blocked filters, confusion between bacterial filters and HME filters, blockage/displacement of tracheostomy tubes.

Different equipment may be available in different organisations and departments. To reduce the risk associated with these variables, each unit should have a training programme and guidance which includes colour photographs and/or exploded colour diagrams of locally agreed breathing circuit configurations, to confirm correct assembly, taking into consideration local specialty and procurement preferences.

Changes to the guidance, checklists or pictures (for operational or equipment availability reasons) should be made by an approved and designated author within each department. Examples are attached, but each unit should produce its own tailored to its requirements and equipment.

The locally prepared exploded coloured diagram or coloured photograph of the required circuit should be used before and during use.

During assembly of the breathing circuit the locally prepared exploded diagram or photograph should be used to:

- Check the oxygen supply is available and functioning.
- Check there is a patent route from the inspiratory gas flow side, all the way though to expiration. Flow through the system should be tested, including the expiratory route **before** connection to the patient.
- Check the pressure setting of any protective CPAP valves (in line with manufacturers guidance) and check the setting of any therapeutic CPAP valve.
- Locate all valves and connectors. These should be visually inspected to check for signs of malfunction - valves may deform, stick or leak.

Bacterial viral filters

- Ensure the correct bacterial/viral filter is in the correct place according to local policy.
    - Inspect filters for sign of clogging and maintain filter change schedule.
    - Write maximum date of change required on the outside of the filter.

Alarms

- Internal alarms – prepare a local specific checklist and set according to manufacturer's guidance. This is particularly important as some CPAP systems will severely reduce fresh gas flow if pressure alarm limits are exceeded.
- Check FiO2, pressure and flow alarms and set to suitable max and min settings.
- External alarms – set suitable max and min limits. These may include FiO2, SpO2, ETCO2, ECG, Respiratory rate, BP/NIBP.
- Record alarm limit settings.

Before commencement of CPAP or NIV

- The patient should be visible/audible to staff, regularly assessed and be cared for in a location, locally agreed as suitable for these patients.
- Assess contraindications or cautions to CPAP/NIV use (taking into consideration BTS guidance).
- Determine and record escalation plan to be used should the patient deteriorate.
- Know your machine, its set up, and common issues (for example is there a battery back-up? Is it charged? Are disconnection alarms present and activated?)
- Report any patient safety incidents or near misses.
- Select suitable patient interface. Ensure face masks and hoods are well fitting and straps adjusted - excessive tightness may distort the seals and promote leaks or pressure sores. Incorporate padding such as nasal bridge protection if required.
- Ensure the patients and monitored parameters are visible from outside the room and where appropriate the patient has a call button within reach.

During use of CPAP

- Ensure gas flows are adequate with CPAP systems and sufficient flow is reaching the patient.
- Confirm that expiratory flow is occurring. If the circuit is designed to exhale to the room, check expiratory flow is present by holding a paper tissue near the expiratory gas flow close to the expiratory port/outlet, and ensure the tissue is blown by the gas flow. If it is not, the fresh air/oxygen flow reaching the patient may be restricted, venting elsewhere or the expiratory pathway may be blocked.
- Watch for misting and 'rain out' in CPAP hoods. If this occurs it may mean expiratory flow is inadequate, which may mean fresh air/oxygen flow to the hood is restricted, even if the hood is inflated.
- Reassess and adjust mask fit.
- Ensure the leak is within the recommended manufacturer leak allowance for the CPAP system.

During use of NIV

- Be prepared. Expect to adjust pressure and FiO2 settings to meet the patient's requirements.
- Reassess and adjust mask fit as required.
- Ensure the leak is within the recommended manufacturer leak allowance for the NIV system.

Patient Progress

- If the patient deteriorates, especially after a change in CPAP valve or NIV settings, check flow, check FiO2 and oxygen supply. Check flow is reaching patient by (where possible) checking presence of expiratory flow.
- If the patient deteriorates after NG insertion or commencing NG feed, check NG position and length. Consider a chest Xray to confirm placement or development of pneumothorax.
- If the patient is deteriorating and escalation is appropriate, intervene promptly.
- Assess and record the patient's degree of breathlessness. Consider using a 0 to 10 scale where 0 is no breathlessness and 10 is worse possible, or a modified Borg scale.[4]
- Clinically examine and assess progress, including observed respiratory rate and clinical signs of changing work of breathing.
- Record ABGs - record 20 minutes after a change in settings or when clinically indicated.
- If the patient deteriorates, promptly review treatment plan and potential timings for escalation if appropriate.

Treatment and monitoring after removal

- If CPAP/NIV has been used therapeutically and discontinued, plan a review to determine if it should be reinstated.
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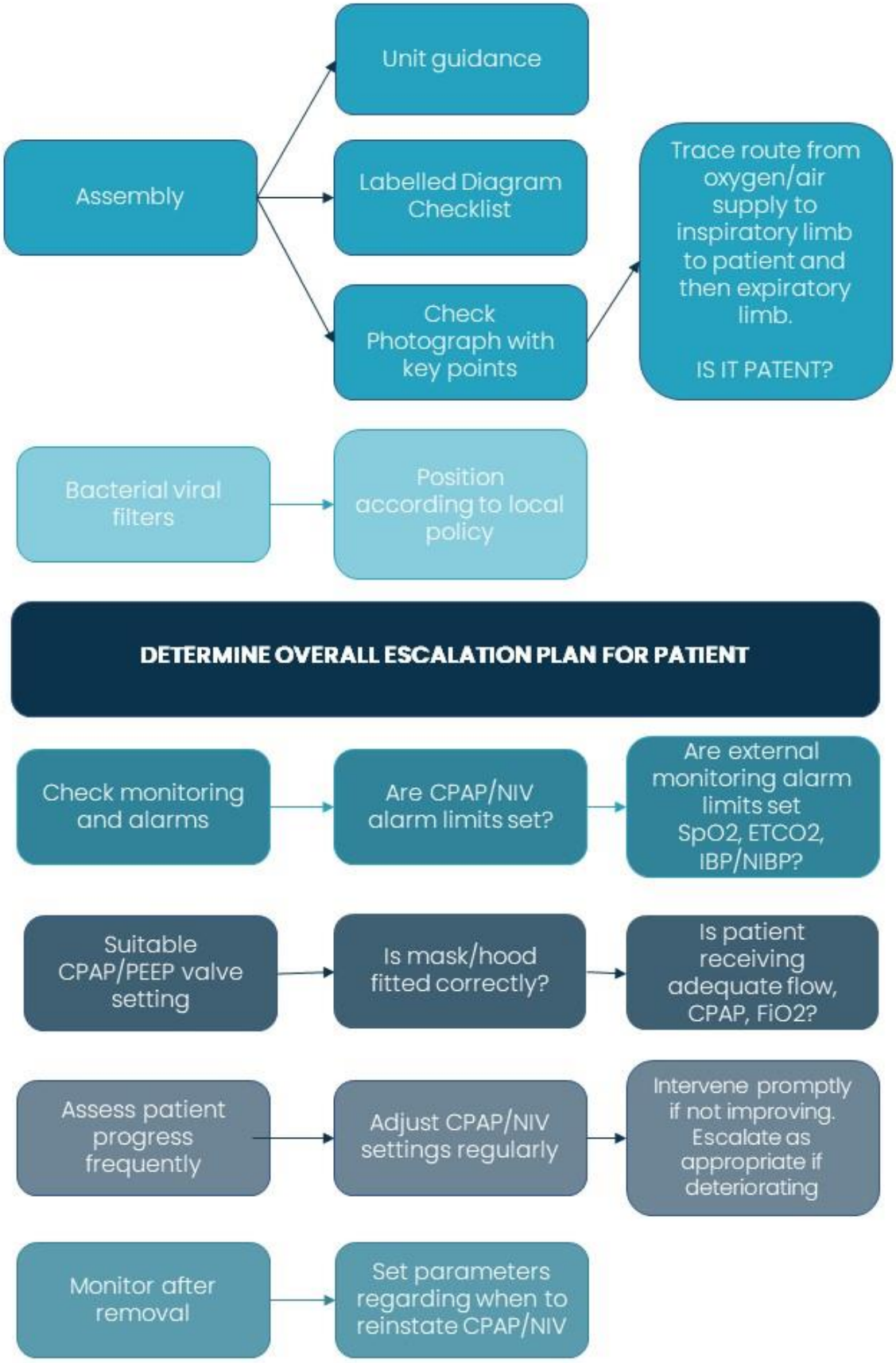
Infection Control

- Change all filters/tubes/equipment in line with manufacturer's recommendations.

References

1. FICM Safety Bulletins (SICC) 1-8 2020-23. https://www.ficm.ac.uk/safety-bulletin
2. Treating COVID-19 patients using Continuous Positive Airway Pressure (CPAP) Independent report by the Healthcare Safety Investigation Branch N1003087 July 2021
3. BTS Management of Acute Hypercapnic Respiratory Failure in Adults
4. Detection and management of dyspnoea. Decavele M, Similowski T, Demoule A. Curr Opinion Crit Care. 2019, 25, 1: 86-94. DOI: 10.1097/MCC.0000000000000574

CPAP/NIV setup flow chart

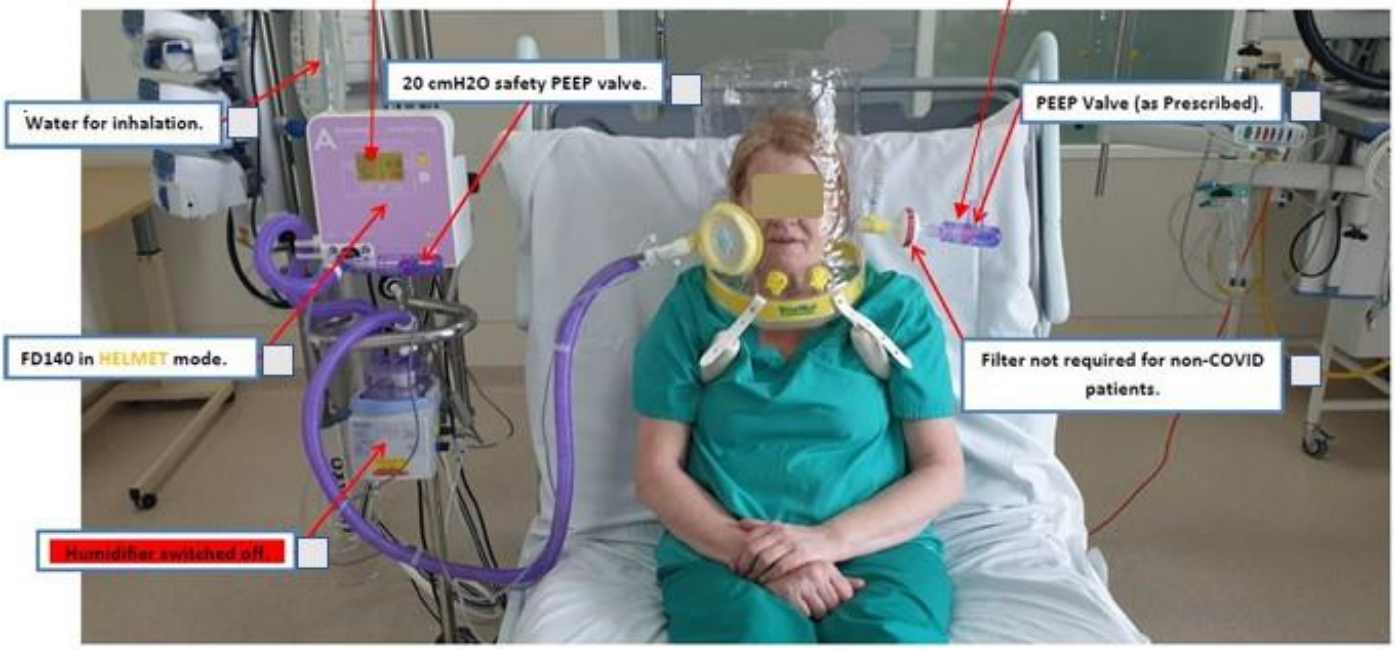


Local set up picture/example for Hood CPAP

Set alarms for flow, pressure and FiO2 (Ensure Pmax set more than 5 cm H2O above CPAP/PEEP valve prescription ☐

Check expiratory flow is occurring by seeing clear movement when holding tissue close to valve expiratory port ☐

FD140 CPAP Hood Setup.



Check and tick off key set up points

Compare equipment to your local set up picture/s and tick off points after checking

This is an example template that would need customising for local equipment

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