Respiratory support for patients with COVID-19 infection: a practical guide

The flowchart below summarises the general approach to the escalation of respiratory support in patients with COVID-19 infection and respiratory failure. The text on the following pages introduces different modes of oxygen delivery and provides practical guidance on the delivery of continuous positive airways pressure (CPAP) and non-invasive ventilation (NIV).

**Important principles**
- Document ceiling of care on admission if possible, and certainly prior to starting CPAP or NIV
- Start CPAP or NIV in discussion with a senior decision maker, ONLY in a side-room or confirmed positive cohort bay on an approved ward. Level 2 PPE is essential
- Before each escalation of oxygen therapy, consider referral for intubation and ventilation

**Escalation ladder for COVID-19 patients in Respiratory Failure (RF)**

- **Covid-19 with hypoxia (SpO₂ <92%)**
  - Indication for endotracheal intubation?
    - **No**
      - Tolerating supplemental oxygen 2-8 L/min (FM, NC, Venturi)
    - **Yes**
      - **Intubate**
        - Video laryngoscope
        - Use expert
        - Minimise staff in room
        - Level 2 PPE
      - Consider trial of CPAP (or NIV in type 2 respiratory failure)
  - Worsening/not tolerating
    - **No**
      - Consider early palliative care measures
    - **Yes**
      - Indication for endotracheal intubation?
        - **No**
          - Consider early palliative care measures
        - **Yes**
          - Senior clinician makes ceiling of care decision using NICE guidance

**Signs of respiratory distress:**
- Laboured rapid breathing
- Appears fatigued
- Tachycardic
- Hypotensive

*Type 1 RF is hypoxic respiratory failure with normal/low PaCO₂
Type 2 RF is hypercapnic with PaCO₂ >6 kPa and coexistent hypoxia
Types of Respiratory Support

- Only use supplementary oxygen if the oxygen saturation (SpO₂) is <94% on air
- Use the lowest flow delivery system necessary to maintain SpO₂ within target range
- CPAP and NIV constitute aerosol generating procedures (therefore side room only, level 2 PPE)

Nasal cannulae (Fig 1)
- **Indication**: mild-moderate hypoxaemia
- **Oxygen flow rate**: 1-6 L/min
- **FiO₂**: 24-50%, depending on pattern flow rate/pattern of breathing
- **Pros**: well-tolerated, widely-available
- **Cons**: low flow oxygen with unpredictable FiO₂

Simple face mask (Fig 2)
- **Indication**: moderate-severe hypoxaemia
- **Oxygen flow rate**: 5-10 L/min
- **FiO₂**: 40-60%, depending on flow rate/pattern of breathing
- **Pros**: widely-available, simple to use
- **Cons**: FiO₂ unpredictable, risk of rebreathing at low flows

If controlled oxygen is required to target SpO₂ 88-92%, use a venturi mask (Fig 3) to deliver a defined FiO₂, which varies with colour of valve.

Reservoir non-rebreath mask (Fig 4)
- **Indication**: severe hypoxaemia
- **Oxygen flow rate**: 15 L/min
- **FiO₂**: 60-90% if bag inflated, depending on mask fit/pattern of breathing
- **Pros**: widely-available, simple to use
- **Cons**: FiO₂ unpredictable, risk of rebreathing at low flows

Continuous positive airway pressure (CPAP)
- **Indications**: severe hypoxaemia without hypercapnia, pulmonary oedema
- **Oxygen flow rate**: up to 15 L/min
- **FiO₂**: unknown, as dependent on flow rates/respiratory mechanics
- **Pros**: may improve gas exchange, may avoid need for intubation
- **Cons**: limited availability, aerosol generating, may delay intubation

Non-invasive ventilation (NIV)
- **Indications**: hypoxaemia with hypercapnia, tiring patient awaiting intubation
- **Oxygen flow rate**: up to 15 L/min
- **FiO₂**: unknown, as dependent on flow rates/respiratory mechanics
- **Pros**: treatment of hypercapnia, may bridge to intubation
- **Cons**: limited availability, aerosol generating, variable tolerance

Intubation and invasive ventilation
- **Indications**: deterioration despite simple measures above, in a patient suitable for full support
More detailed guide to the use of CPAP and NIV

Continuous positive airway pressure (CPAP) and non-invasive ventilation (NIV) are both forms of non-invasive respiratory support and use similar equipment (see below). However, there are important differences between these treatments, and they are not interchangeable.

Continuous positive airway pressure (CPAP)

What is CPAP?
CPAP is fixed positive pressure applied to the airways throughout the breathing cycle, to splint open the respiratory tract. It is used at home during sleep to splint open the upper airway in patients with obstructive sleep apnoea, but can also be helpful in splinting open the lower airways to improve gas exchange in patients with hypoxic respiratory failure, e.g. due to infection or pulmonary oedema.

The CPAP machine generates positive airway pressure by generating a flow of gas towards the patient, to elevate the pressure in the mask/airways. For patients with COVID-19 the standard CPAP pressure will be 10-12 cm H₂O. This is a relatively high pressure, but has been chosen based on the experience of COVID-19 in China and Italy.

Indications for CPAP
In COVID-19, CPAP will be used primarily to treat type 1 respiratory failure, i.e. severe hypoxia without hypercapnia. In this situation the patient is usually breathing hard enough (i.e. moving enough gas in and out of the lungs) but gas exchange is impaired so they are hypoxic.

Many such patients need invasive ventilation, in which case CPAP may be used as a holding measure (‘bridge’), whilst intubation is awaited. In this case, the ICU team should be informed before therapy is commenced. In other patients CPAP may be sufficient, enabling the risks of intubation to be avoided. It may also be used as the ceiling of care, in which case this should be clearly documented at the earliest opportunity.

CPAP set-up
Set the CPAP machine to 10-12 cm H₂O; if no CPAP machine is available, an NIV machine may be used in CPAP mode. There are various ways of delivering CPAP, which could be via:

- a CPAP machine
- VIVO-40 in CPAP mode

It is also possible to deliver CPAP from a wall gas supply, without a CPAP or NIV machine

To reduce environmental contamination:

- When starting therapy, put the mask on the patient before turning the machine on
- When stopping therapy, turn the machine off before removing the mask from the patient

Have supplementary oxygen available for the patient to use when taking breaks from the machine, e.g. to eat or drink and have mouth care
Non-invasive ventilation (NIV)

What is NIV?
NIV is sometimes called BiPAP, bi-level or NIPPV. All these terms refer to positive airway pressure that varies during the breathing cycle, to provide not only an elevated baseline airway pressure (expiratory positive airway pressure, EPAP, which is equivalent to CPAP), but also an elevated inspiratory pressure (inspiratory positive airway pressure, IPAP), which is triggered when the patient starts taking a breath in.

Indications for NIV
NIV is primarily used for conditions in which the patient is not managing to get enough gas in and out of the lungs. This may be due to respiratory muscle weakness (e.g. muscular dystrophy), high airways resistance (e.g. COPD) or poorly compliant chest wall (e.g. obesity, kyphoscoliosis).

In patients with COVID-19 infection, NIV is indicated for patients with hypercapnic respiratory failure. This may be due to a combination of COVID-19 and an underlying condition, or alternatively to severe COVID-19 infection with very poor gas exchange and/or fatigue. In the latter case, NIV should only be used as a bridge to urgent intubation, or when NIV is the ceiling of care.

NIV set-up
These will vary depending upon the patient’s underlying condition. For example, without COVID-19 infection, usual pressure settings would be:
- **COPD**: Titrate up to IPAP 20 and EPAP 4 cm H\(_2\)O (high airways resistance and hyperinflation, therefore need high pressure to ventilate)
- **Obesity**: Titrate up to IPAP 20 and EPAP 8 cm H\(_2\)O (reduced respiratory system compliance, therefore need high pressures to ventilate plus likely coexistent obstructive sleep apnoea needing high EPAP)
- **Kyphoscoliosis**: Titrate up to IPAP 20 and EPAP 4 cm H\(_2\)O (low respiratory system compliance, therefore need high pressure to ventilate)
- **Respiratory muscle weakness**: use low pressures of around IPAP 12 and EPAP 4 cm H\(_2\)O (the compliance of the respiratory system is usually normal, so patients are easy to ventilate)
- **NB**: If a patient on home NIV for one of the above conditions comes in with their home machine, they will usually need an increase in their usual pressures. Their usual respiratory circuit with a vented mask should be entirely replaced with a circuit as per COVID-19 guidance with a non-vented mask, viral filter and expiratory port.

In patients with Covid-19 infection, aim to set an EPAP of 8-10 cm H\(_2\)O, with an IPAP of 20-25 cm H\(_2\)O. The difference between the EPAP and IPAP is the ‘pressure support’ driving inspiration and helping to increase ventilation.

To reduce environmental contamination:
- When starting therapy, put the mask on the patient before turning the machine on
- When stopping therapy, turn the machine off before removing the mask from the patient

Have supplementary oxygen available for the patient to use when taking breaks from the machine, e.g. to eat or drink and have mouth care.
Respiratory circuit

Mask type
CPAP is usually delivered in the Trust through ‘vented’ masks, whereby the patient exhales through small holes in the mask itself. However, in patients with Covid-19 this would lead to the venting of contaminated gas into the surrounding area.

Therefore, in line with national guidance, for suspected and confirmed Covid-19 we will use masks without holes (‘non-vented masks’), which do not allow expiration via the mask. *It is therefore vital that an exhalation port (i.e. a hole through which expired gas can escape) is included in the circuit, to avoid death by asphyxiation.*

Viral filter
Both CPAP and NIV generate high flows of gas, much of which will escape into the surrounding environment. They are therefore aerosol generating procedures and should be undertaken only in a side room, with medical and nursing staff using level 2 personal protective equipment (PPE).

To mitigate this risk and reduce environmental contamination as far as possible, a bacterial/viral filter should always be present between the mask and the exhalation port (see below). This should be changed every 24 hours, or sooner if obviously wet. External water humidifiers should not be used in hospital, and should be removed temporarily from home machines.

Supplementary oxygen
CPAP and NIV machines generate positive pressure using a flow of room air. Many patients will also need supplementary oxygen. This is added from the wall supply via an oxygen inlet port included in the circuit (below), which allows entrainment of up to 15 L/min of oxygen.

Due to variable total flows with CPAP or NIV, it is not possible to predict the FiO₂ for a given oxygen flow rate. If oxygenation cannot be maintained in the target range with 15 L/min oxygen, and CPAP is not the ceiling of care, refer for consideration of intubation.

Full circuit
It is essential that all components are assembled/connected in the following order:

- Mask
- Viral/ bacterial filter
- Entrained oxygen inlet (far-side of the filter to reduce environmental contamination)
- Expiratory port (far-side of the filter to reduce environmental contamination)
- Respiratory tubing
- Second filter
- CPAP or NIV machine, as appropriate
General tips

Mask Fitting
Apply mask from bridge of nose to crease of chin, ensuring mask cushion is inside; tighten gently using the straps so mask is fitted before the machine is turned on (excess tightening will prevent the mask moulding to the patient’s face).

Review the bridge of the nose regularly and avoid skin blanching, which is a risk factor for a nasal pressure area. Alternatives, such as an F30 oronasal mask, do not cover the nasal bridge. Avoid pure nasal masks as pressures drops when the patient opens their mouth.

Terminology
Ti: the amount of time per inspiration, usually set as 0.8 seconds
Ti min: the minimum amount of time per inspiration, usually 0.3 seconds
Ti max: the maximum amount of time per inspiration, usually 1.2 seconds

Backup rate: the backup respiratory rate per minute, usually 12, but if the patient is tachypnoeic set at 10 below their respiratory rate

Rise time for NIV: time to maximal inspiratory pressure, usually on a scale of 1 to 9, with 1 being the shortest (i.e. maximal IPAP almost immediately) and 9 the longest. Usually start at 3, but if the
patient is tachypnoeic they may need a shorter rise time. Conversely patients who have trouble synchronising with the NIV may need a longer rise time.

*Ramp:* refers to the time in minutes it takes to get to the intended pressures. If a patient is struggling to tolerate the pressure, a 5 min ramp may help.

*Inspiratory and expiratory triggers:* the sensitivity at which the machine accepts a patient’s inspiratory or expiratory effort and triggers a change from IPAP to EPAP or vice versa. On the Vivo40 they go from 1 (easiest to trigger) to 9 (hardest).

**Troubleshooting**

1. Check the mask and circuits all look correct and there are no breaks or slits in the tubing
2. Check there is an expiratory port in place
3. Check to see if there is a significant leak (e.g. > 20 L/min). If so tighten, refit or change mask
4. Change expiratory filter (needs to be changed every 24h and can get clogged). Ensure machine is switched off first to avoid excessive aerosolization of virus.
5. Set backup rate to 10 below the patient’s respiratory rate
6. If the patient is not syncing correctly:
   a. *Alter the rise time:* usually lengthening to help with syncing (more gentle increase in pressure for the patient) but if the patient is tachypnoeic a long rise time (>3) may provide inadequate pressures and ventilation, so consider shortening (<3)
   b. *Adjust triggers:* inspiratory trigger is the most important to adjust and may need to be increased or decreased by 1 or 2 (as may the expiratory trigger) but remember what number you’ve changed it from in case you worsen the situation
7. Low lung volumes (tidal volume, Tv, should be 5-7 ml/kg, e.g. around 360ml for a 60kg woman): increase IPAP or increase Ti to increase the tidal volume.

['General tips’ – Turnbull and Hynes]