# The National Ventilator Project

The National Ventilator Project (NVP) was established by Minister Ebrahim Patel to provide locally sourced medical ventilators through an accelerated process that will deliver on the aggressive timescale dictated by the advance of the Covid-19 pandemic in South Africa and other African countries.

# CPAP and Covid-19

About 20% of individuals who show symptoms of Covid-19 present with some form of respiratory distress because their lung function is compromised. Oxygen exchange in the lung's air sacs (alveoli) is reduced because of the lung tissue's response to the virus. These individuals require hospitalization and supplementary respiratory support, the modality of which depends on the severity of their symptoms. Approximately 75% of the hospitalized patients will only require high-flow oxygen therapy, provided by a simple nasal cannula that can be administered in a standard hospital ward or field hospital.

More serious cases require some additional gas pressure in their airways in order to inflate the air sacs and improve the efficiency of oxygen exchange to the blood. CPAP devices are simple, non-invasive ventilators that provide this excess pressure and supplementary oxygen via a mask or hood. The mask or hood also prevents the patient's exhaled air from contaminating health workers. High-flow nasal cannula can also be employed, but there is a risk of viral contamination associated with this therapy.

CPAP therapy has these attributes:

a) It does not require the use of intensive care or high-care facilities, requiring only oxygen from a standard ward wall supply, and possibly a medical air supply.

b) It is non-invasive: The respiratory gas is provided by a mask or hood, not via intubation. The implication is that the clinical skills required for its application are less stringent than for invasive ventilation techniques.

c) The patients do not require sedation, and are conscious and cooperative

Patients whose ability to breathe spontaneously is severely compromised will require the use of invasive therapy where the patient is sedated and intubated in an intensive care environment, and an invasive ventilator takes control of the patient's breathing cycle.

# CPAP Device Options

The NVP ran accelerated process to identify suitable CPAP devices that achieved a minimum clinical specification determined by senior Intensivists, and local manufacturers who are competent to design and manufacture these devices. A CPAP system consists of two major components:

a) A gas supply that provides the required pressure, flow and fractional oxygen concentration ($FiO_2$).

b) A patient circuit that delivers the gas to the patient via a mask (half- or full-face) or hood.

**Gas supply**

Three classes of gas supply device were investigated:

a) Turbine blowers with supplementary oxygen injection. Requires electrical power and oxygen via a rotameter. **This type of gas supply will not be provided by the NVP.**

b) Entrainment devices that use a high velocity oxygen jet to entrain ambient air. Requires standard hospital oxygen supply (~400 kPa).

c) Blenders that mix oxygen and compressed medical air in the required proportions. Requires

standard hospital oxygen supply (~400 kPa) and medical air supply (~400 kPa).

**Patient circuit**

All patient circuits include the following common components:

a) 2 meter 22 mm tube.
b) Overpressure relief valve (40 cm $H_2O$).
c) Peep valve (0-20 cm $H_2O$).
d) Anti-asphyxia valve.
e) Viral filter to prevent contamination from exhaled air.
f) Mask or hood.

Three mask/hood options were investigated:

a) Half-face masks (similar to common masks used in hospitals for anaesthesia).
b) Full-face masks based on scuba masks.
c) Hoods that enclose the patient's head, with a neck seal.

**Operation parameters**

CPAP therapy provides three controllable therapeutic parameters that the clinician must optimize for each individual patient:

a) Gas flow rate that is adjusted at the gas supply device to match the patient's need and comfort. Flow rates of up to 60 lpm are required, depending on the patient's breathing effort.
b) Positive End-Expiratory Pressure (PEEP) that is adjusted at the PEEP valve to match the patient's need and comfort. Recommended PEEP pressures lies in the range 5-10 cm $H_2O$.
c) Fractional inspired oxygen ratio ($FiO_2$) that is adjusted at the gas supply device to obtain the required oxygen saturation level for the patient, measured using a pulse oximeter.

# CPAP Devices available from NVP (as at 10 June 2020)

The Solidarity Fund has approved funding that allows the procurement of a subset of the above device options. Two gas supply devices will be procured by NVP with the first tranche of funding, one entrainment device and one blender device:

**UCL/Mercedes Ventura device**

- This device was developed by UCL and Mercedes in the UK to provide CPAP therapy, and is used in many hospitals around the world.
- It is an entrainment device that require a standard hospital "wall" oxygen supply at ~400 kPa. It is provided with a standard SANS oxygen probe.
- **The device has three controls: (i) gas flow on/off, (ii) gas flow rate (no dial indicator), (iii) $FiO_2$ (no dial indicator).**
- The device can provide an oxygen concentration to the patient of 30-100% $FiO_2$.
- Flow rates in excess of 80 lpm are obtainable.
- The interface to the patient circuit is a standard 22mm-tapered male port.
- This is the preferred device for hospital beds that have only wall oxygen.

**SAVE-P blender device**

- This device is based on the gas blender used by the Penlon Nuffield 200 ventilator.
- It is a blender device that require a standard hospital "wall" oxygen supply at ~400 kPa and a standard hospital "wall" medical air supply at ~400 kPa. It is supplied with hoses that are fitted with standard SANS oxygen and air probes.
- **The device has three controls: (i) gas flow on/off, (ii) gas flow rate (with dial indicator), (iii) $FiO_2$ (with dial indicator**).
- The device has a pressure gauge that measures the pressure supplied to the patient circuit.
- The device can provide an oxygen concentration to the patient of 21-100% $FiO_2$.
- Flow rates in excess of 80 lpm are obtainable.
- The interface to the patient circuit is a standard 22mm-tapered male port.
- This is the preferred device for hospital beds that have both wall oxygen and medical air.

Each CPAP system will consist of a gas supply unit and a patient circuit utilizing a half-face mask. Spare viral filters will be provided, but it is expected that the hospital will have to have an ample supply of these filters to handle the expected consumption. A pulse oximeter will be provided with each CPAP system.

Should further funding be obtained the remaining device options will be procured, i.e. an additional entrainment device, and additional blender device, full-face masks and hoods.

**All hospitals must work with their oxygen engineering teams to ascertain their VIE outflow, and downstream flows and pressures to specific ward areas, before deploying these devices.**