

MMed and DCH Lectures

CPAP and High-flow respiratory support

Sept 13, 2021

Prof Trevor Duke

Aims

- Explain how CPAP works
- Describe the different types of CPAP

CPAP and COVID

- Oxygen if $SpO_2 < 92\%$
- If still hypoxic → prone position, and give more oxygen
- If still hypoxic → use CPAP / High-flow
- Indications for CPAP
 - Severe respiratory distress or hypoxaemia despite oxygen therapy + prone position

Where COVID is endemic...

- Acts like any other pathogenic respiratory virus in children
 - Most susceptible children at risk of severe disease
- Occasionally causes immune over-activation
- Often a co-pathogen

Treatment of severe COVID

- **Triage:** Assess for emergency signs
- **Emergency treatment:**
 - Give oxygen
 - Intravenous fluid to correct dehydration if present (10-20ml/kg)
 - If still signs of shock: adrenaline infusion. Put 6mg adrenaline in 1000 ml normal saline and run at 0.5ml/kg/hour (0.05 mcg/kg/min)
- **History / examination**
- **Diagnosis: look for secondary bacterial sepsis**
- **Treatment**
 - **Antibiotic treatment** for sepsis (ceftriaxone + flucloxacillin)
 - **Dexamethasone 0.15mg/kg Q12**
- **Monitor** vital signs, SpO₂, hydration state, and blood pressure
- **Supportive care:** avoid over-hydration, maintain blood glucose, nutrition, prone positioning





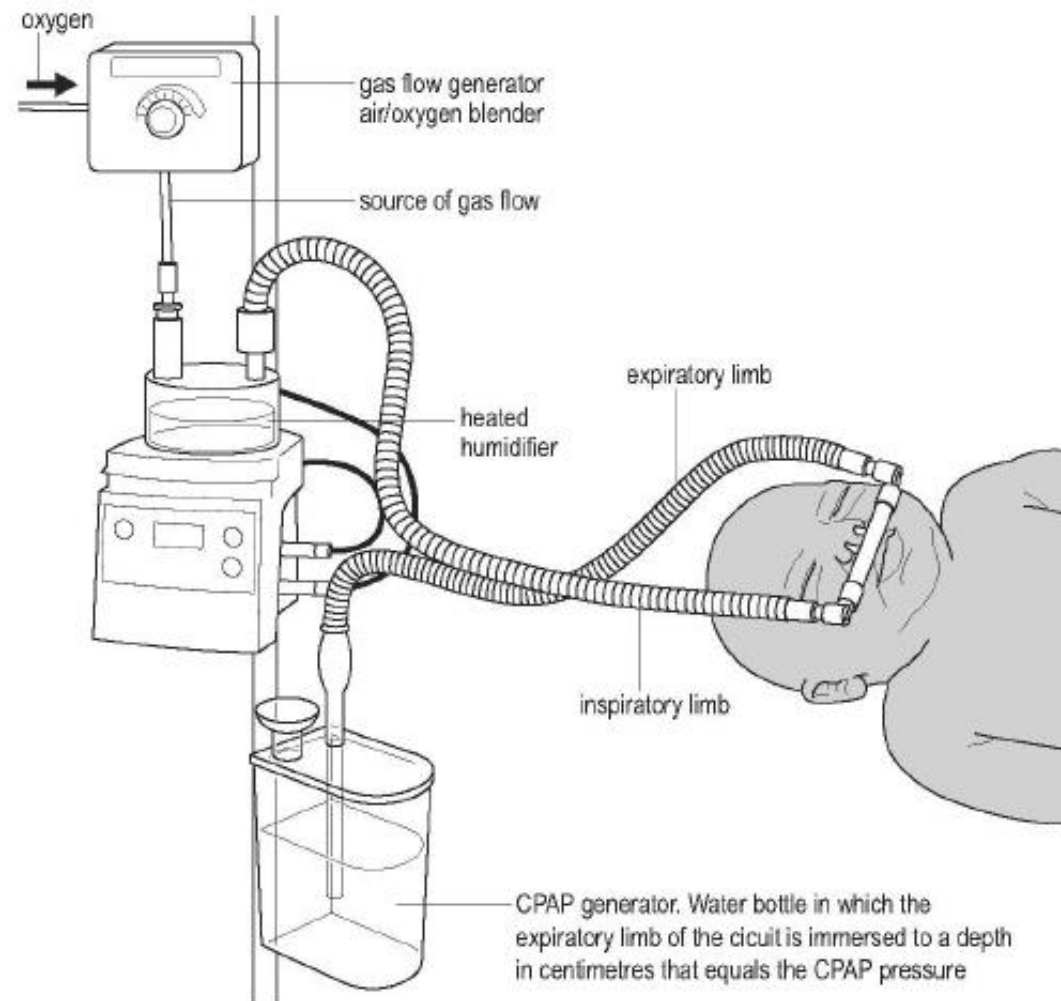
CPAP and High Flow respiratory support

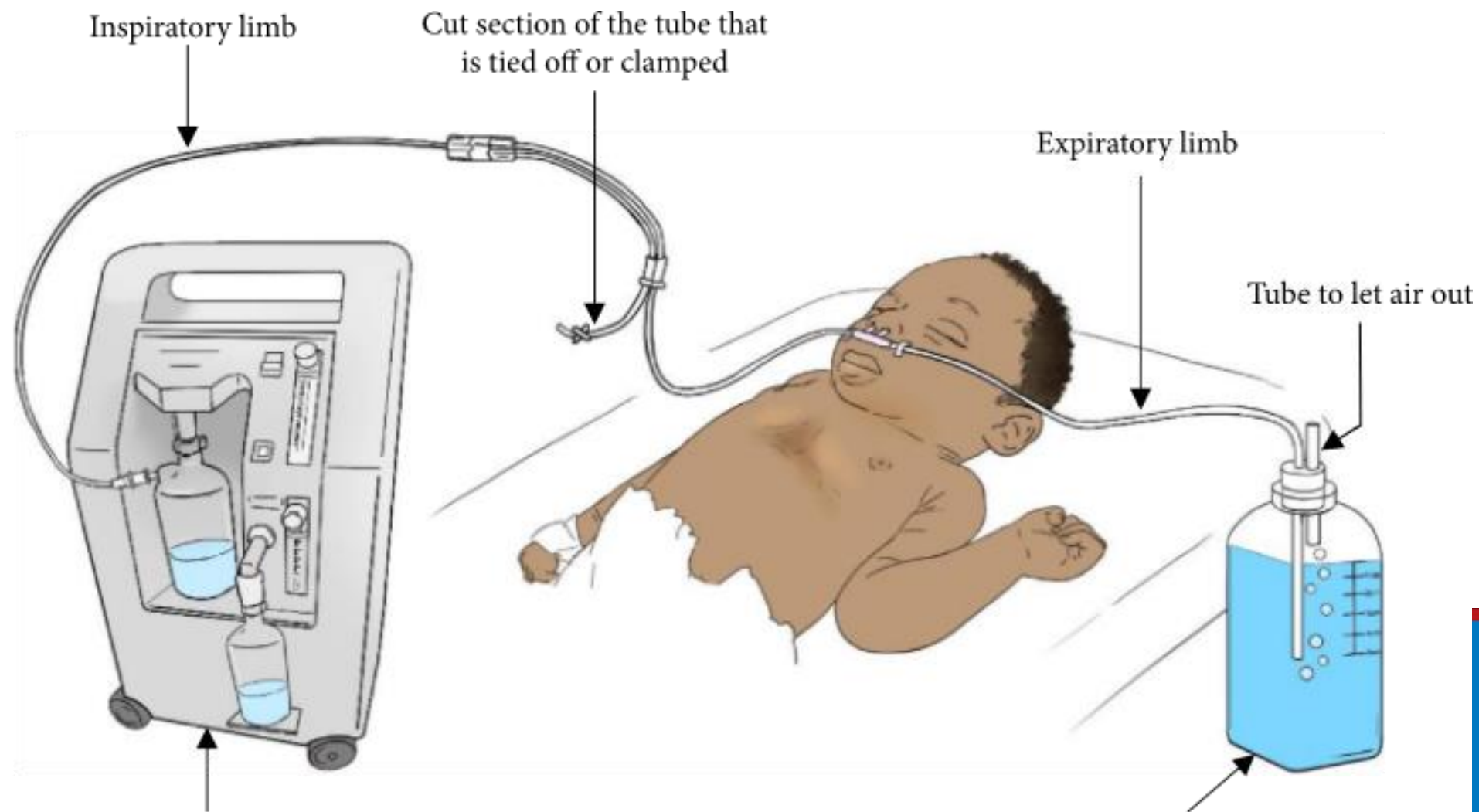
- Bubble CPAP
 - Concentrator
 - Fisher & Paykel bubble-CPAP machine
- CPAP
 - ventilator
 - CPAP driver
- High flow nasal cannula oxygen therapy
 - Fisher & Paykel high flow device
 - Airvo

Components of CPAP

- **Source of air / gas flow**
 - Oxygen concentrator / cylinder
 - Compressor
 - CPAP driver
 - Ventilator
- **Oxygen source** – can be same as gas flow source, or blended oxygen / air
- **Patient interface with 'air-tight' seal**
 - Nasal prongs
 - Mask – full face, nose and mouth, nose
- **Circuit with adjustable resistance on expiratory limb**
 - Pressure valve (CPAP driver or ventilator) in mask, circuit or ventilator
 - Under-water seal (bubble-CPAP)
- **Humidification source**

Bubble-CPAP





Oxygen concentrator with a humidifier. Oxygen flow rate is initially set at 5 L/min.

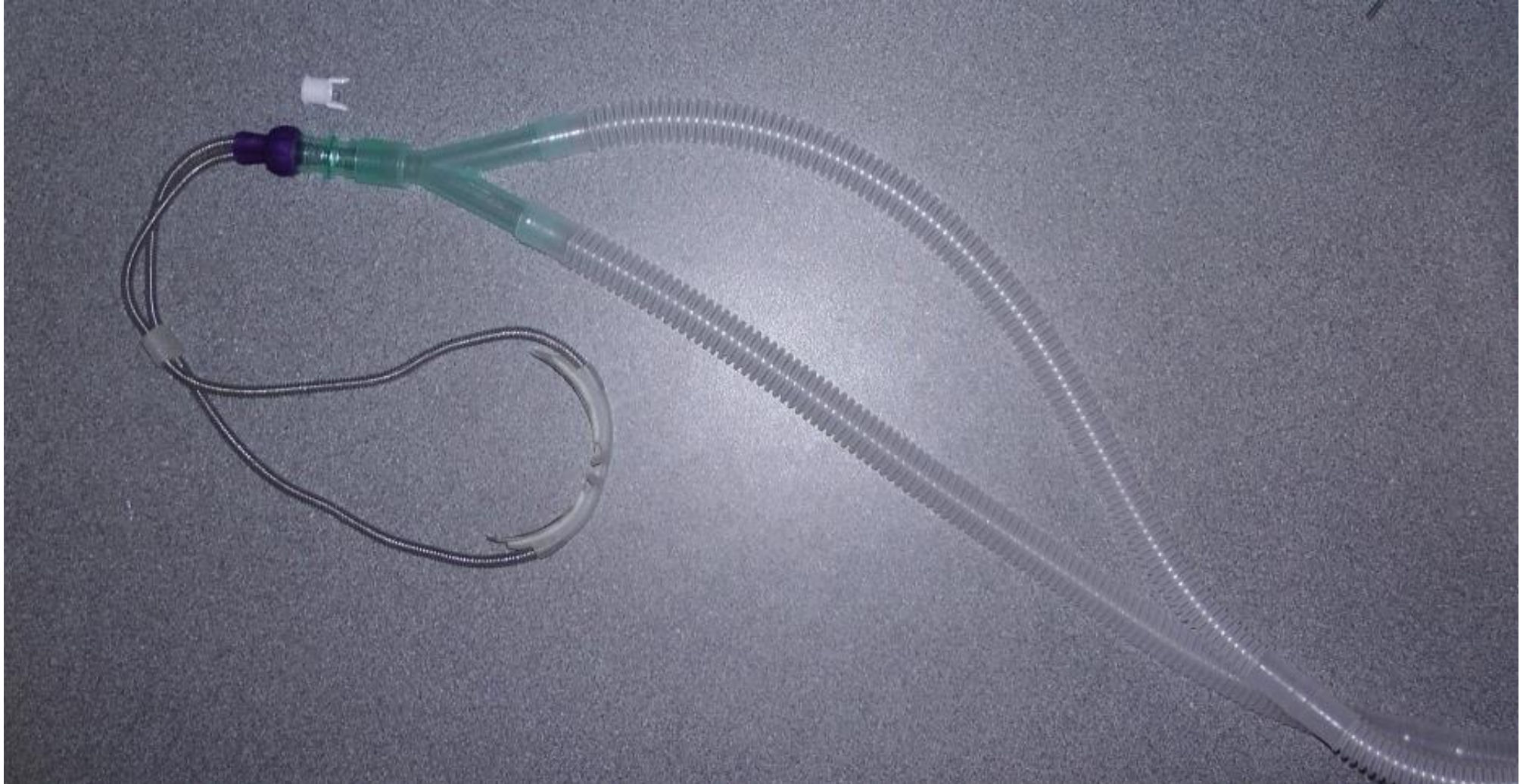
Calibrated transparent bottle in which the expiratory limb is immersed. The depth of immersion in centimetres is equivalent to the CPAP pressure (e.g. 5 cm below water surface = 5 cm H₂O). Constant bubbling indicates that CPAP is being generated.



Oxygen therapy
for children



Optiflow nasal prongs











Bubble-CPAP patient interface

- Modified oxygen prongs
 - Easy to make, cheap
 - Resistance sometimes means the bubbling is due to tubing resistance, not airway resistance
 - Safeguard: turn machine on, connect circuit, check for bubbling *before* applying nasal prongs to the patient
- Optiflow nasal prongs
 - Expense and availability
 - Low resistance so no problem of auto-generation of bubbling at usually required flow rates

Complications of CPAP

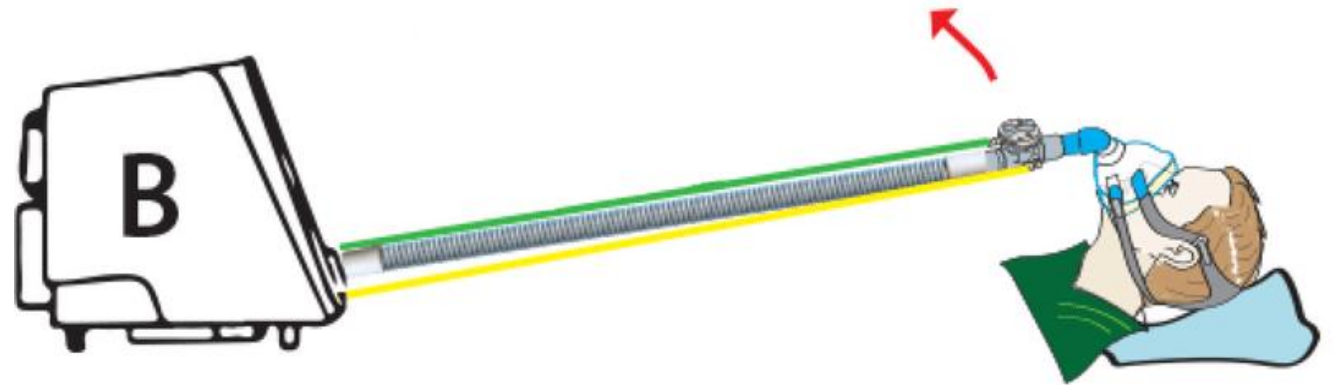
- Pressure areas
 - Depends on the patient interface
- Gastric distension
 - Prevent with a nasogastric tube
- Pneumothorax
 - Rare, but be alert to at-risk children (Staph pneumonia with pneumatoceles, PjP, asthma).

CPAP ventilators

- **Source of air / gas flow**
 - Compressor in CPAP driver or Ventilator
- **Oxygen source** – blended oxygen plumbed into ventilator
- **Patient interface with 'air-tight' seal**
 - Mask – full face, nose and mouth, nose
- **Circuit with adjustable resistance on expiratory limb**
 - Pressure valve (CPAP driver or ventilator) in mask, circuit or ventilator
- **Humidification source**
 - Built in heated water humidifier (+/- hot wire that ensures humidification in the long circuit)

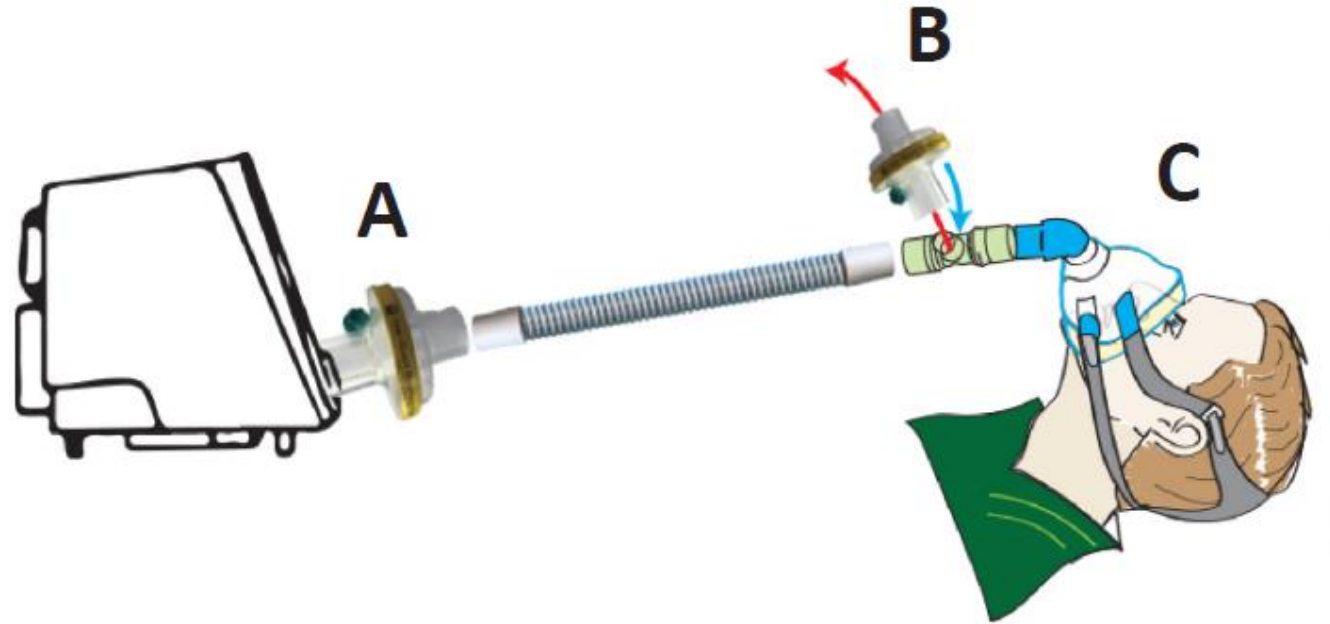
CPAP ventilators

- A. Vented mask
Single lumen passive circuit
- B. Non-vented closed mask
Single lumen active circuit
exhalation via holes in the circuit (exhalation port)
- C. Non-vented closed mask.
Double lumen circuit
Exhaled air goes back to the machine via the exhalation tube, controlled by exhalation valve in the machine



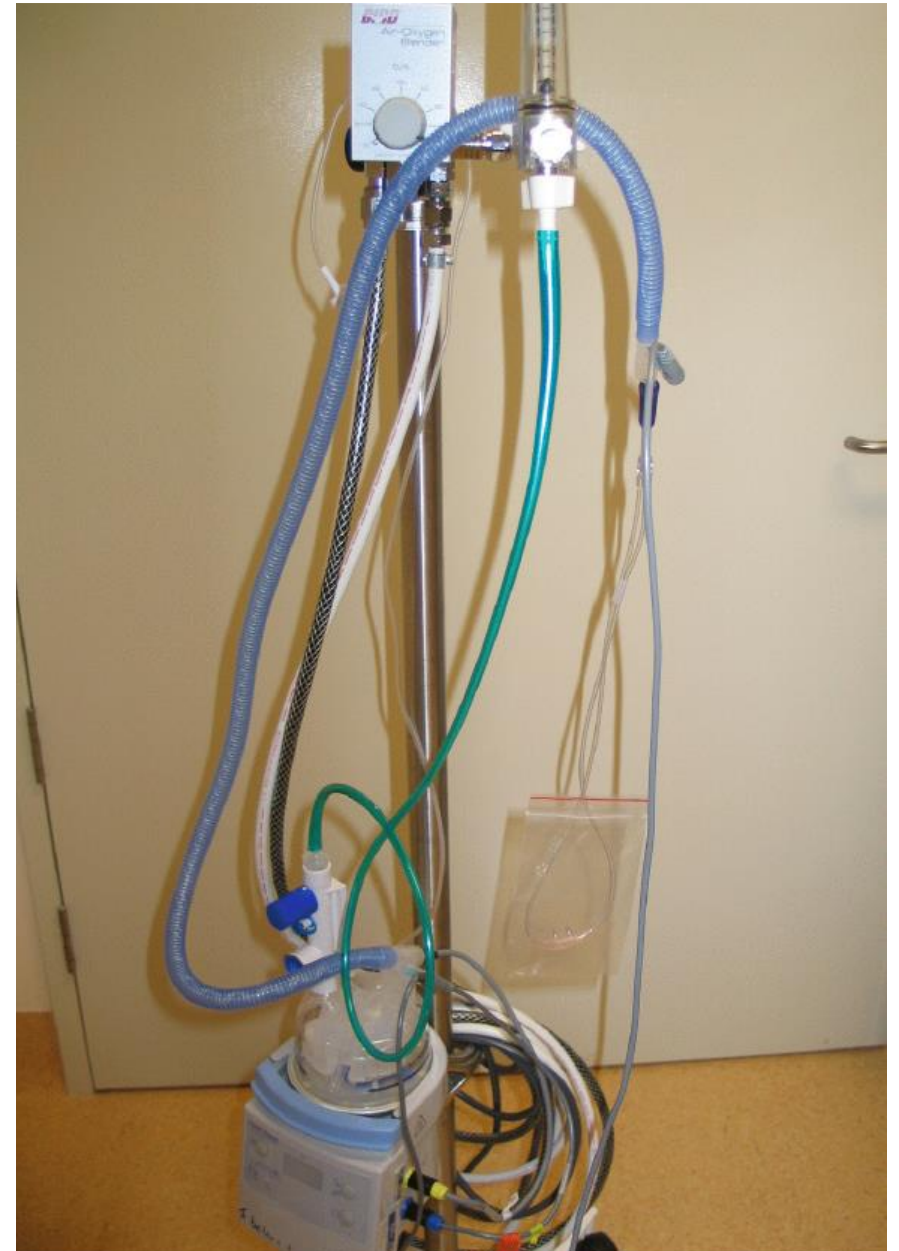
Viral filters: needed at 2 points

1. To protect the surroundings
filter at the exhalation valve
2. To protect the patient from contamination from the environment (machine)
filter at the gas outlet start of inspiratory circuit



High flow nasal cannula oxygen therapy

- Heated-humidified high flow
- Nasal prongs (Optiflow)
- **2 litres per kg per minute**
- Humidify at 37° C
- Blended oxygen
- Start FiO_2 0.5-1.0
- Watch RR, HR, chest in-drawing
- Reduce FiO_2 as signs improve, aim for <0.5 (50%)
- Generates 4-8 cmH_2O PEEP



Airvo 2

- Air flow generator which can deliver warmed humidified air at a flow rate of between 5 and 45 litres per minute.
- Inbuilt oxygen blender and oxygen analyser, thereby allowing specific amounts of oxygen to be added to the air flow and monitored precisely via an LED display.
- Cheaper than currently used circuits (MR850) - \$1850 v \$3000.
- Ease of use



F&P AIRVO™ humidifier with integrated flow generator

The AIRVO generates high flows of warmed and humidified respiratory gases, delivered to the patient through a variety of nasal, tracheostomy and mask interfaces.

Powerful yet compact, it provides the ideal solution for delivering humidified high-flow therapy across the continuum of patient care.



Respiratory distress score

		Mild = 0	Moderate = 1	Severe = 2
1	Hypoxaemia	Mild hypoxaemia SpO ₂ 90–93%	Moderate hypoxaemia SpO ₂ 85–90%	Severe hypoxaemia SpO ₂ <85%
2	Chest wall retraction	None or minimal	Moderate chest wall retraction	Marked chest wall retractions, tracheal tug
3	Respiratory sounds wheeze and crackles	Good air entry on auscultation Minimal or some wheeze	Moderately reduced air entry. Wheeze and some crepitation on auscultation	Loud audible wheeze without stethoscope. Poor air entry on auscultation Widespread crepitations.
4	Respiratory rate / min	<40	40-60	>60
5	Heart rate / min	<140	140-170	>170

Paediatric monitoring and response chart

UR Number

Weight:

Diagnoses:

Name

Age:

Length / height

Frequency of observations:



Date																				
Time																				
AIRWAY / BREATHING	Temp °C	≥ 39																	>39	
		38-38.9																	38-38.9	
		36-37.9																	36-37.9	
		<36																	<36	
	Respiratory Rate (bpm)	≥ 80																	≥ 80	
		70																	70	
		60																	60	
		50																	50	
		40																	40	
		30																	30	
		20																	20	
		10																	10	
	0																	0		
SpO ₂ (%)	95-100																	95-100		
	90-95																	90-95		
	80-90																	80-90		
	70-80																	70-80		
	<70																	<70		
Oxygen	L/min																	L/min		
Respirat. distress	Severe																	Severe		
	Mod.																	Mod.		
	Mild																	Mild		
	Normal																	Normal		
CIRCULATION	Heart rate (bpm)	≥ 200																	≥ 200	
		190																	190	
		180																	180	
		170																	170	
		160																	160	
		150																	150	
		140																	140	
		130																	130	
		120																	120	
		100																	100	
		90																	90	
		80																	80	
	70																	70		
	60																	60		
	<60																	<60		
	Cap refill	≥ 3 secs																	≥ 3 secs	
		< 3 secs																	< 3 secs	
BP	Systolic																	Systolic		
	Diastolic																	Diastolic		
	Mean																	Mean		
DISABILITY	AVPU response to stimuli	Alert																	Alert	
		Verbal																	Verbal	
		Pain																	Pain	
		None																	None	
Pain score (/10)																		Pain		
Blood sugar level																				
Treatments given																				
Actions taken																				



Technical problems

Problems identified	Solutions
<p>CPAP circuits split if they are washed multiple times or stepped upon. This leads to air leaks and ineffective CPAP.</p> <p>Oxygen concentrators run at high flow rates (at the limits of their performance), may produce lower concentration of oxygen</p> <p>Some humidifiers are ineffective, and if using high flows for prolonged time can result in drying of airway secretions and clinical failure</p>	<p>Need to check integrity and performance of all equipment regularly, at least weekly.</p> <p>Use of robust circuits that can be autoclaved or cleaned will reduce the risk of splits and leaks</p> <p>Need an oxygen analyser to check flow rates and oxygen concentration weekly</p> <p>Need to ensure effective humidification if using high gas flows</p> <p>Need an environment free from dust to avoid concentrator malfunction</p>

Clinical problems

Problems identified	Solutions
<p>Important to identify comorbidities, severe malnutrition, anaemia, HIV, alternative diagnoses such as congenital heart disease</p> <p>Delay in administration of CPAP</p> <p>Nursing shortages</p> <p>Registrar availability to review patients on CPAP</p>	<p>Guideline</p> <p>A detailed ward round each day to identify problems</p> <p>Monitoring and response chart</p> <p>Ongoing training for nurses and doctors</p> <p>Nurse: patient ratios not less than 1:4 in the high dependency / intensive care area</p> <p>A paediatric doctor to be available 24 hours a day and review patients on CPAP regularly, no less than every 4 hours</p>

System problems

Problems identified	Solutions
Equipment maintenance	<p>Need a trained nurse to maintain the oxygen concentrators, nasal prongs, circuits, spare parts.</p> <p>Nurses need to be familiar with equipment, cleaning, routine maintenance and use.</p> <p>Mechanism for procurement of spare parts.</p>

Prepare pillows, rolled-up blankets / towels
Oxygen / CPAP
Monitor SpO₂
Optimise comfort
At least 2 people assist the patient
to turn prone & be comfortable.



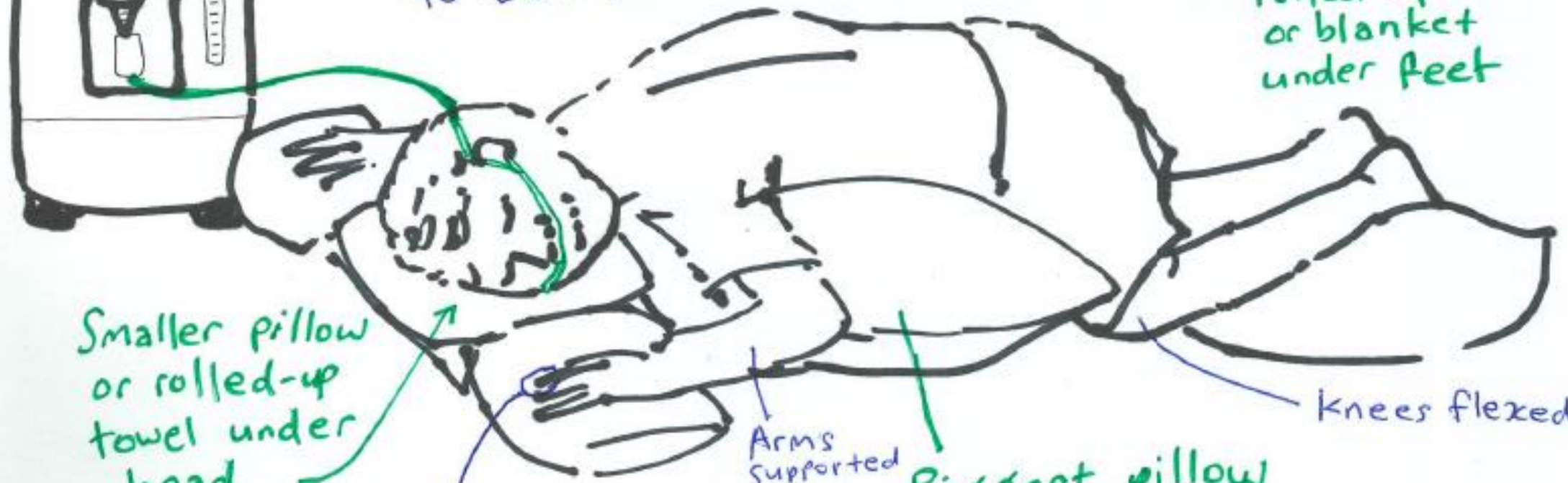
Pillow or rolled up towel or blanket under feet

Smaller pillow or rolled-up towel under head

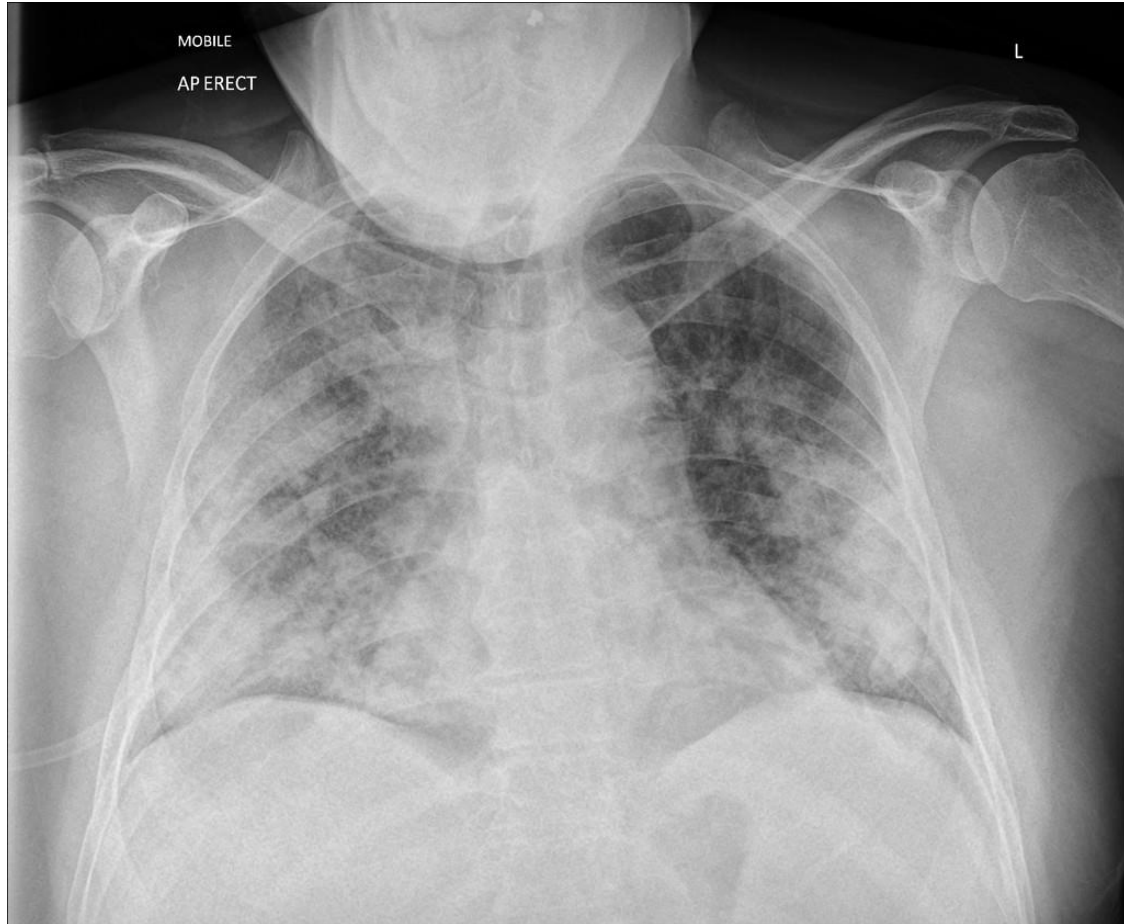
Arms supported

Knees flexed

Biggest pillow under chest & abdomen







What works in COVID?

- Oxygen
- Dexamethasone
- Antibiotics if secondary bacterial infection
- Restrictive fluids
- Prone positioning
- CPAP
- Close clinical monitoring
- Aspirin
- Zinc