Utility of respiratory support equipment beyond the COVID pandemic: applications of CPAP devices
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Advisory Aim
The aim of this MAC Advisory is to support the use of oxygen and respiratory devices in multiple clinical situations, to strengthen the critical care pathway at district health service level.

Background
The COVID pandemic has initiated the rapid procurement, development and uptake of various respiratory support devices. Questions have been raised as to whether there is any role for these devices post COVID. These devices deliver oxygen to patients in a variety of clinical settings, and are anticipated to have a utility and application beyond pure COVID respiratory support. One such example is CPAP where both simple and more complex devices have been rolled out in large numbers.

This document is intended to be a reminder of the indications and clinical utility of CPAP therapy, rather than to sway opinion regarding its usage. In clinical medicine, it is accepted that there is no "one- size- fits- all" therapy for respiratory support, and the decision on therapeutic modality will rest with the responsible physician attending to the patient (often further influenced by what equipment is available and local/ institutional protocols).

The arrival of the SARS-CoV2 virus and the ensuing COVID 19 pandemic has initiated an extensive debate on ventilatory support modalities and their appropriateness/ utility in COVID and consequently non-COVID pathologies as well. Currently this debate, specific to COVID, has been relatively unencumbered by the presence of robust, high quality evidence from large well conducted trials- and has been heavily informed by medical opinion, observational work and translation of work done for other respiratory pathologies. This is however not the case for non COVID respiratory support where there is a vast literature base providing us with evidence on the utility of the various modalities.

Without being tied up in the minutiae of these debates, it must be recognized that irrespective of whatever device delivers the support- there are only a few mechanisms by which they work. These take the form of oxygen therapy, plus mechanical respiratory assistance in the form of a positive pressure (with the ability to manipulate the pressure waveform during the respiratory cycle in more complex devices).

This advisory should be read in conjunction with the MAC advisories previously released on infection control practices and the implementation of High-Flow Nasal Oxygen (HFNO 24th June 2020). The implementation of HFNO and CPAP/BiPAP must take infection prevention and control interventions into account. These have been very well-defined by the WHO as supported by the MAC advisory.

Review of the application of CPAP in clinical settings
Continuous positive airway pressure (CPAP) as a form of respiratory support therapy has been available and clinically relevant for nearly 100 years. It is not a newcomer, but rather a familiar and well tested therapy. As one of the simplest and easiest to use of the support modalities, providing supplemental oxygen, and a continuous airway pressure during the respiratory cycle. The positive pressure that is applied on expiration assists in achieving and maintaining alveolar recruitment and promotes an optimal functional residual capacity (FRC) ie the volume of the lungs at expiration, as well as improving airflow in those patients that have intrinsic positive end expiratory pressure (PEEP) i.e. in those that because of airway resistance, a rapid respiratory rate or large tidal volumes they cannot exhale all the air in the lungs prior to taking the next breath. These effects have a significant impact on respiratory mechanics and gas exchange parameters, as well as cardiovascular performance by way of reduced preload, afterload and consequently myocardial work. The positive pressure in the circuit during inspiration also provides some inspiratory assistance. The net result of these effects is a better aerated lung [better ventilation /perfusion (V/Q) matching] with improved oxygenation, reduced work of breathing, and reduced myocardial work. It is these effects that essentially inform the indications for and utility of CPAP.

Before discussing these, it is important to remember that the therapy described can come in many forms depending on the technology used to administer it. The most basic of these is represented by pneumatically driven fixed flow devices, with variable or fixed PEEP. These will be best remembered by older clinicians as the “wall CPAP/ bubble CPAP” devices that were ubiquitous in the general wards pre the 2000’s. During these times, it was a familiar sight to see patients in various medical and surgical wards receiving CPAP with the intention of supporting respiration, improvement of symptoms and avoidance of admission to critical care. With the advent of more complex, technically advanced and servo-controlled ventilators, the CPAP therapy went from being a stand-alone device to being an available “mode” on the ventilator. The consequences of this were that one device could deliver multiple therapies (convenience, reduced need to keep and maintain multiple devices for respiratory support) but also that provision of these modalities of support moved from being predominantly ward based to now being critical care based.

The use of oxygen delivery devices requires high volume oxygen delivery, the National Department of Health has completed oxygen delivery audits in 160 central, regional and district hospitals to identify maintenance and infrastructure enhancement including oxygen reticulation required to provide high-volume flow to high-care and ventilated COVID or medical beds.

Recommended current and future use of simple CPAP devices

The absence of the simple devices did not mean that the therapy had suddenly become any less relevant or clinically applicable, rather that it just changed the location of the therapy to a more central area. What COVID has taught us is that the centralization of these types of simple therapy can place undue pressure on constrained resources, and that revisiting simple ward-based supportive measures is essential to promotion of social justice by allowing provision of the best possible care for all by appropriate resource allocation.

While the more complex servo-controlled, turbine or pneumatically powered devices can provide extra inspiratory support (advantageous in certain pathologies), there remain multiple applications, backed by robust evidence where simple CPAP is indicated and beneficial. These are applicable in the complete range of care areas, ranging from prehospital, to the emergency unit, the general ward and in the ICU.

A complete systematic review of clinical utility and outcomes of CPAP therapy is beyond the scope of this document; however, a search of literature from Pubmed, WoS and Google Scholar has been undertaken to provide some substance for the claims relating to CPAP. The search was limited to CPAP usage in adolescents and adults, in prehospital (EMS) and hospital environments. Neonatal indications while robust, are not in the scope of this document as the devices in question have never been tested specifically in this setting. For this document, CPAP usage related to sleep disordered breathing (SDB) has also not been included, since there is a paucity of work looking at the use of fixed flow devices specifically in SDB. This does however raise another interesting possible application for in-hospital, ward based use as physically and physiologically there is no reason why it should not be a practical option to manage these patients and there is a space here for a locally conducted trial. It is also beyond the scope of this document to provide a complete protocol for use with indications, contraindications and assessment of parameters indicating success or failure of CPAP therapy; however, this would be an important next step.

The result is that we have a range of clear and robust indications where CPAP therapy has been shown to improve symptoms, time to symptom resolution, reduce hospital stay, reduce potential pulmonary complications, and reduce the need for escalation to invasive mechanical ventilation and critical care bed utilization.

Acute cardiogenic pulmonary oedma. Here CPAP therapy has a significant impact on dyspnoea reduction, improvement of LV function and resolution of pulmonary oedema. It is a highly effective form of therapy and in Europe and North America is instituted even prehospital by Emergency care practitioners. Depending on severity, this patient cohort may be managed across ward and critical care environments. Multiple trials have also demonstrated that use of a device which supplies pressure supported breaths as well as CPAP (BiPAP) in this scenario provides no advantage.

Exacerbations of Chronic obstructive lung disease (COPD). Early application of CPAP in these patients allows reduction in work of breathing and is a well recognized support modality suitable for ward based care to avoid deterioration while medical therapy takes effect. The important proviso is that there must be no indication that there is excessive carbon dioxide (CO_2) retention- as evidenced by an acidosis (i.e. a pH neutral patient). If CO_2 retention, non-invasive ventilation with BiPAP support is better- this would however be an indication for escalation to the ICU environment anyway.

Non cardiogenic type 1 respiratory failure from multiple causes. Here, early ward or casualty based initiation of CPAP therapy can have a significant effect on reducing progression to need for mechanical ventilation. This has been borne out repeatedly in the literature, and includes pathologies that frequently are encountered like pneumocystis jirovecii (PJP) and other community acquired pneumonias. Here, as well as symptom improvement, avoidance of invasive mechanical ventilation, and outcome benefit- it can also be used as a good "ceiling of care" in patients deemed not suitable for critical care, where there is a not-insignificant salvage rate.

Post-operative respiratory support in Thoraco- abdominal procedures. This patient cohort has a significant risk of developing post operative pulmonary complications which contribute significantly to patient morbidity and mortality, to increased need for mechanical ventilation, ICU bed utilization, and increased length of stay with resultant cost implications. Early initiation of CPAP therapy in patients undergoing thoracic surgery (particularly lung resection) and upper abdominal procedures demonstrates reduced atelectasis, improved oxygenation, reduces need for mechanical ventilation and in some reduces length of stay. If CPAP is ineffective this is an early indicator for the need to escalate care and in so doing optimises appropriate resource allocation. It must be highlighted here that, based on the African Surgical Outcomes Study (ASOS), perioperative mortality in South Africa (and rest of Africa) is significantly higher than our European and north American counterparts, despite having a far younger average population. The failure to prevent and manage perioperative complications is the greatest threat to outcome. Simple perioperative interventions that can have a positive impact such as CPAP should therefore be embraced wherever possible.

Respiratory distress and impending evolution of respiratory failure in haematological malignancies. The early application of non invasive modalities of respiratory support in most immunosuppressed states correlates with lower mortality and less requirement for invasive mechanical ventilation. This is particularly true with haematological malignancies where early ward-based application of CPAP in those who are neutropaenic with pulmonary infiltrates and hypoxaemic will provide the most benefit. Here this benefit is both a composite of survival benefit and reduced admission to critical care for more advanced support.

Infection Prevention and Control Interventions for clinical wards using HFNO and CPAP- Shaheen

The infection prevention and control (IPC) risks from high flow nasal oxygen (HFNO) and continuous positive airway pressure (CPAP) are twofold. Both these procedures are considered aerosol generating procedures (AGP) and require appropriate IPC (airborne) precautions to protect the healthcare workers and patients. Staff should wear a well fitting respirator plus a face shield or goggles, to protect the eyes, mucous membranes and to prevent inhalation of small aerosols. Bed spacing and ventilation is essential to reduce airborne transmission. Increased distance of beds to 3m between the centre of one bed to the other increases the distance between patients and also allows essential equipment to be placed next to each patient without cross contaminating surfaces between patient care equipment. To reduce airborne transmission, negative pressure is considered ideal, but the system must ensure that the air from the clinical area is exhausted out to the open air. Alternatively air should be filtered via a High Efficiency Particulate Air (HEPA) if recirculated (not recommended). Increased ventilation also helps to reduce transmission. The recommended ventilation for AGP areas is 12 air changes per hour (ACH)[1] or the delivery of 160l/sec/patient.[2]

The second risk is from the circuit tubing itself. These tubes are designed to be disposable. The lumen of the nasal oxygen tubes is too narrow to reprocess because neither steam nor chemicals can penetrate the lumen adequately to guarantee sterility. Therefore it is recommended that **each circuit be for single patient use only**. For CPAP systems that use spacers and require reprocessing, these must be cleaned after each patient use. They can be disinfected by either soaking in a chlorine solution for 30 minutes, then rinsing with water and air drying **or** washing with soap and water, wiping down with 70% alcohol and air drying- the latter is preferred since chlorine irritates epithelial lining of the respiratory tract and increases the risk of infection.

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[1] Western Cape Government: Guidance for Emergency Centres in the Western Cape during the COVID-19 Response, 2020.

[2] NDOH: COVID-19 Disease: Infection Prevention and Control Guidelines Version 2 (21st May 2020)

Training provided for the implementation of CPAP and HFNO

With the aim of scaling the implementation of HFNO and CPAP ahead of ventilation, key online training and mentorship programs have been released with CME accreditation for doctors, paramedical staff, nurses and medical technologists. The key elements of training include the identification of patients requiring high-flow with increased oxygen FiO2, the implementation requirements, patient level mask requirements, and setup of the patient circuit and devices. The training available online should be combined with mentorship towards certification of nurses and doctors for the treatment options.

Conclusion:

As elucidated above, there remains a very strong argument for the provision and implementation of simple CPAP devices for ward and critical care based care in the abovementioned circumstances . This is not necessarily a complete list of indications- but rather those with the most compelling evidence base. The nature and simplicity of these devices makes them ideally suited to regional and district hospitals, and even beyond, with their ease of use, cost competitiveness and the fact that they are locally manufactured being even greater attraction.

Further work is required before the CPAP/BiPAP equipment can be implemented in neonatal and paediatric population. The use is limited in these populations due to the fixed calibration of the oxygen delivery volumes and FiO2.

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