

Measuring CO₂ during use of the Air-Wave Protector full face snorkel mask

Introduction:

The Corona crisis has induced a worldwide shortage of FFP2 protecting masks for medical personnel, causing many health workers to be insufficiently protected or unprotected. This has sparked many innovative projects to develop a reusable protective mask. One of the strategies employed is to use the Subea Easybreath full face snorkel mask and modify it into a protective mask by adding a special connector and a filter. One of these initiatives is the Air-Wave Protector which combines the mask with a PAPR (Powered Air Purifying Respirator). PAPR are frequently used outside of the medical world to protect workers from toxic gas and particles, among others in the asbestosis, chemical and welding industry. This has the advantage that the devices and the filters used are validated according to legal norm. Because these devices have never before been combined with a snorkel mask, we wanted to determine if there was any significant rebreathing causing hypercapnia.

Method:

A healthy female subject of 37 years has worn the Air-Wave Protector for 2 uninterrupted hours while simulating working conditions. There were intermittent exercises consisting of intense exercises consisting of jumping jacks during 4 minutes and performing medium-intense exercises by walking around the bed in a U-shape and kneeling down at beginning and end during 15 minutes. This is a more strenuous use than would be expected during ICU care, even taking into account the repositioning of patients for prone ventilation.

The saturation, ECG, respiratory rate and expiratory CO₂ were continuously measured. Blood pressure (BP) was measured every 5 minutes. There was an arterial blood sample before the start of the experiment, after 1 hour of use and after 2 hours of use. Furthermore, the comfort was assessed during use as well as any subjective complaints were assessed.

Results:

The CO₂ did not rise during use, neither as measured by the capnogram or as measured by the arterial pCO₂. The other parameters (RR, BPM, BP) showed normal rise during physical exercise with fast normalization during rest. The last measurement was taken just after a cycle of 15 minutes of exercise.

There was no headache present during the entire session. The heat under the mask was not an issue due to the fresh flow (170L/min). The only place that got a little warm was the contact point between the plastic and the skin, but this was very mild. The pressure from those contact points were minimal. After removing the mask there were some very discreet pinkness around the face, that was almost completely gone after 10 minutes. There was no bruising or painful sensation at any time.

Communication was not hindered due to noise. Test subject had no problem hearing and being heard. A person with a naturally soft voice or who mumbles might be less easy to understand. There was no condense forming on the snorkel, both in rest and during exercise. Furthermore, the range of movement of both arms and legs was not hindered by the belt with the PAPR at the back or the tube connecting the PAPR to the mask, neither during normal activities or during jumping jacks.

The seal of the mask was assessed by feeling around the edge of the mask for air leak. This was not present in rest, except through the frontal expiration valve. However, during talking an occasional cold air leak could be felt at the chin, and very infrequently the forehead. This leakage does not have to be a problem with this configuration as the inward leakage is minimized by the flow of 170L/min produced by the PAPR. The filtered air that is blown into the mask is dry, so the mouth and lips have a

tendency to dry out. This can be resolved by breathing through the nose and putting some lip balm on beforehand.

timing	pCO ₂	pH	exp CO ₂	BP	BPM	RR
before start	4,84	7,421	4,8	127/79	82	17
after 1 hour	4,99	7,416	4,9	108/82	92	13
after 2 hours	4,07	7,503	4,2	140/86	134	25

Conclusion:

The Air-Wave Protector has shown no physiological or subjective signs of hypercapnia both in rest and during exercises. During testing there were only small issues with comfort that were easy to overcome, but overall the comfort of wear was excellent and the duration of wear could have been easily prolonged.

When compared with common practice (of FFP2 mask and protective goggles) there are several potential advantages: the filter used can be FFP3 or higher giving a better degree of filtration, there is less pressure on the face due to the CPAP-like configuration, there is less problem of heat due to the fresh air flow, the entire face is protected and sealed off in contrast the now used protective goggles or face shields and because the mask can be decontaminated and reused it is a more efficient method to protect health care workers compared to disposable FFP2 masks.

The Air-Wave Protector is however not certified for this use and in the current crisis setting it is impossible to perform in a timely manner all the tests necessary to achieve this certification. Considering the setting it should be considered to be more permissive in the conditions for clinical applications of new medical equipment.