DOI: 10.1111/apa.15521

ACTA PÆDIATRICA NURTURING THE CHILD WILEY

How a portable negative pressure incubator for COVID-19 was created with minor modifications

The COVID-19 pandemic is affecting all age and patient groups, including pregnant women and neonates. There is no evidence at the moment to show vertical transmission and intrauterine virus infections in foetuses when women develop COVID-19 pneumonia in late pregnancy. However, infections in neonates are higher than in older children, according to the largest population-based study to date, and this means that infants may also face a higher risk of severe respiratory failure.[1] Dong et al's national study of 2143 paediatric cases in China from 16 January to 8 February 2020 showed that 10.6% of the severe and critical cases were under one year of age. The incidence rates for the other paediatric age groups studied were: 1-5 years (7.3%), 6-10 years (4.2%), 11-15 years (4.1%) and 16 years plus (3.0%).

Aerosol generating procedures carry the highest risk of transmitting infection and this has particular relevance in neonatal settings, where continuous positive airway pressure (CPAP) and high-flow oxygen therapy are commonly used. Guidance for units treating neonates with COVID-19 recommend full personal protective equipment protection for CPAP and high-flow therapies of at least two litres per minute. They also suggest keeping the expiratory limb of the CPAP in the incubator whenever possible.[2] The American Academy of Pediatrics recommends that COVID-19 patients should be placed in negative pressure rooms or in incubators.[3]

With the rise in COVID-19 patients across the globe, many hospitals are facing an unprecedented crisis with regard to equipment and infrastructure. A negative pressure room is necessary to contain this new virulent killer and hospitals are racing against time, budget and infrastructure to create them.

We recognised the need for negative pressure incubators for neonatal patients with COVID-19. To address this, we created a negative pressure incubator using readily available and affordable materials. We used a Neo Shield, Model Neo 1001 incubator (Neokraft Medical Pvt Ltd, Karnataka, India) and drilled numerous small holes in the last 40cm of the suction tubing. This tube was then fixed over the end wall, where the infant's head is placed, and the roof of the incubator (Figure 1, Panel A). The suction tube was then passed through the underwater seal drain system, which contained 100 mL of 1% sodium hypochlorite, to disinfect the exhaust air before attaching it to the wall suction unit (Figure 1, Panel B). The inlet for the surrounding airflow was provided through a space surrounding the caudal end window. Negative pressure rooms require a minimum of 12 changes of air exhaust per hour or a flow rate of 145 litres per second per patient.[4] The suction pressure was kept at 200 millibars using the Hagen-Poiseuille equation to create approximately 12 air changes per hour. We assessed the efficacy of the physical barrier, and the negative airflow through the suction tubing, by aerosolisation of a fluorescein solution under ultraviolet light. Aerosolisation was created within the incubator using the Cirrus nebuliser (Medi Safe International, Delhi, India) and the movement of aerosolisation towards the suction was visible

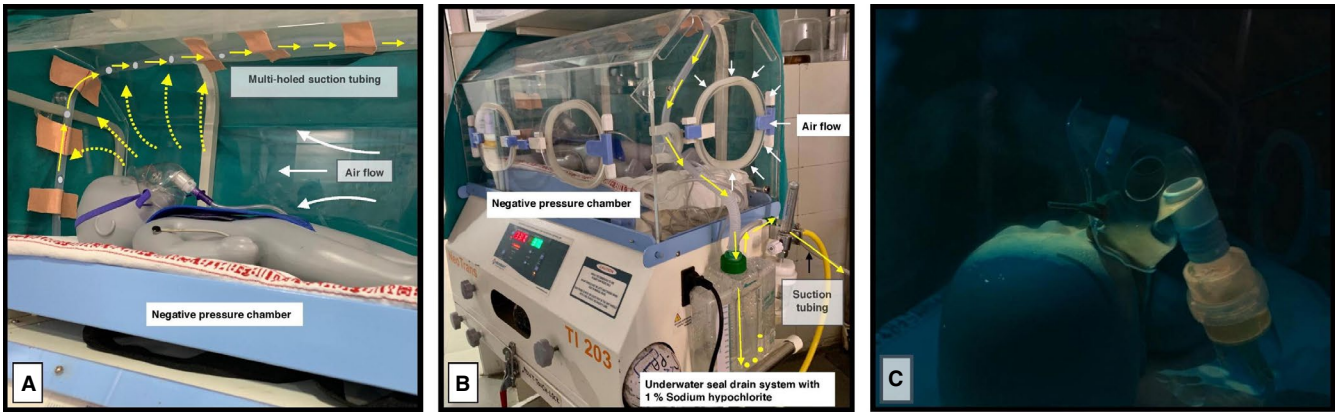

FIGURE 1 A, Exhaust air flowing through the multi-holed suction tubing fixed on the wall of the incubator. B, Suction tubing passing through the underwater seal drain system. C, Fluorescein aerosolisation seen under ultraviolet light

(Figure 1, panel C). However, we were not able to find a method to quantify the fluorescein dispersion.

This assembly has a number of advantages. It can be easily constructed using readily available and affordable materials and this also make it useful in low-resource settings. The unit is portable, which means that it can be used in different locations like neonatal intensive care units and labour rooms. It provides an effective physical barrier that creates an enclosed continuous negative airflow and it allows oxygen therapy and aerosol generating procedures in patients with COVID-19 patients, while preventing aerosol dispersion.

The unit could also be used in the post-COVID-19 era for containing other respiratory infectious diseases, like tuberculosis.

We realise that further research and testing are necessary to quantify the effectiveness of this modified unit in reducing the exposure of healthcare workers to aerosol generating procedures. However, we believe that this is an ingenious device and that a better design based on these principles can be developed in the future.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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