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Virus containment box for retinopathy of prematurity screening and laser

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Purpose: Health care workers are susceptible to contracting infection with COVID-19 by aerosol transmission. This is a risk while examining and/or treating an un-sedated neonate in retinopathy of prematurity (ROP) screening and treatment. But screening for neonates for ROP and treating with laser, when required, should not be delayed to avoid the blindness. We describe a cost-effective method of containing aerosols generated during such a procedure in an un-sedated baby. **Methods:** An acrylic transparent containment box was prepared to accommodate an average-sized infant. The box had four walls and a roof. The floor was open to place the container box over the baby. The walls have two types of openings, large ones to allow passage of hands to examine the baby, small ones to enable passage of oxygen tubing when required. A simulation was created to examine the impact of aerosol spray on examining healthcare personnel. **Results:** The cost of the acrylic box was negligible. It could be assembled locally with available acrylic sheets and craftsmen. It was not difficult to examine the baby inside the box, and the simulation demonstrated that it protected the health personnel from the aerosol contamination. **Conclusion:** The described method is likely to increase healthcare personnel's confidence not to delay or deny ROP screening and laser treatment and save the babies from blindness.

Key words: COVID-19, innovation, ROP screening, virus containment box

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Coronavirus disease 2019 (COVID-19) is a pandemic that has affected the entire world.[1,2] Novel severe acute respiratory syndrome coronavirus-2 (SARS CoV-2) causing COVID-19 infection spreads through the droplet, aerosol, and surface contact.[3] Transmission is possible through asymptomatic patients.[4,5] Although transplacental and breast milk transmission of COVID-19 has not been proved, the disease can occur in newborns.[3,6,7] Affected newborns may remain asymptomatic or show varying degrees of respiratory distress and may require hospital admission.[3,6-8]

Retinopathy of prematurity (ROP) screening and management is categorized as emergency care during the COVID-19 pandemic, though the Indian ROP society has recommended less frequent hospital visits.[9,10] ROP screening and laser procedure performed in a conscious and crying baby are expected to generate aerosol and increase the possibility of infecting the treating ophthalmologist and paramedical personnel. Though there is no study on the quantum of aerosols produced by a crying baby during an eye examination, universal precaution is the best available solution. An extra barrier of protection, in addition to the standard personal protective equipment (PPE), could reduce aerosol contact.[11] An ideal system would be examining the baby and performing laser procedures, when required, inside an incubator. With this objective, we designed an aerosol containment box, which, we believe, could act as a physical barrier to direct exposure to the aerosol.

Methods

The design of the box

The containment box is of a rectangular design made from commercially available transparent acrylic sheets. The top of the box was angulated to have a slanting wall. The detailed measurement of the box is depicted in Fig. 1a. Transparent acrylic sheets are commercially available in different sizes and thicknesses. We can purchase these sheets at car/bike remodeling shops and in workshops where number plates for different automobiles are made. We used single 4 feet × 4 feet rectangular acrylic sheet of 5 mm thickness. With help from a biomedical person, with a diploma degree from an industrial training institute, the sheet was cut into desirable pieces as per the design with a laser cutting machine available at the automobile workshop. The holes on either side of the box lengthwise were fashioned. The pieces were glued to each other using industrial grade adhesive (Anabond). The baby gets enough air through the hand holes, and additional oxygen can be supplemented through single-use oxygen tubes that could reach the baby's face/nostril passed through small side holes [Fig. 1b].

Simulation

We tested the efficacy of the box in aerosol containment by following a simulation. A plastic eye drop bottle containing diluted 20% sodium fluorescein dye was kept near the baby mannequin's mouth. The examiner and the assistant wore PPE, N95 mask, and a transparent overhead projector (OHP) sheet was secured with

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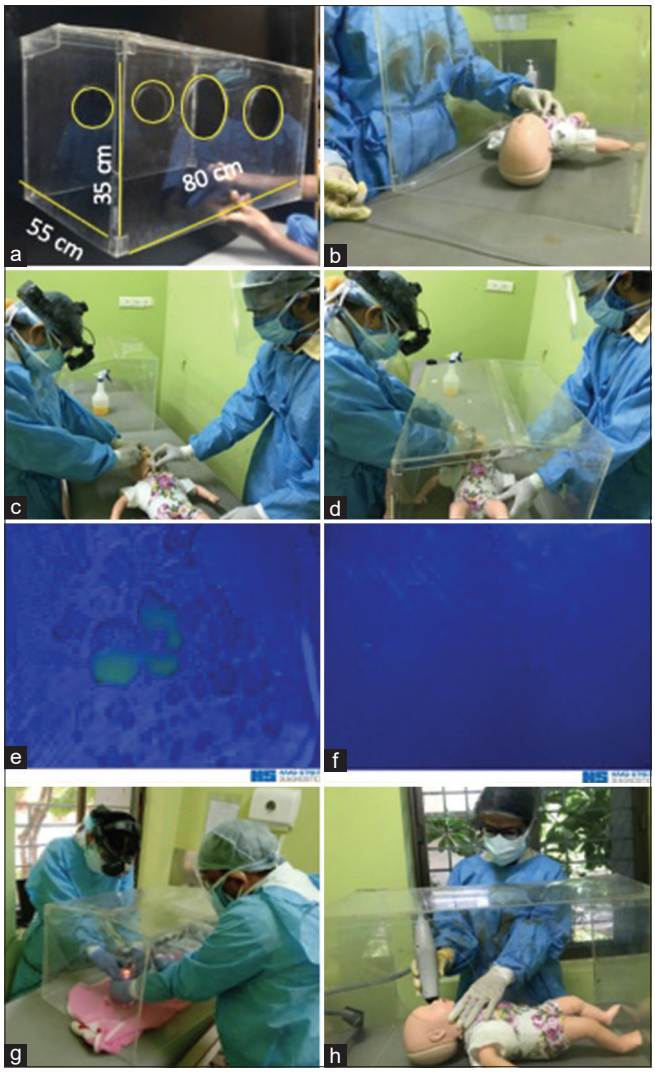

Figure 1: (a) design of the virus containment box weighing 3 kg; (b) oxygen tubing through small side hole; c and d- simulation of ROP screening, both examiner and assistant wearing the OHP face shield; the assistant squeezes the bottle to create sodium fluorescein dye aerosol, done without (c) and with (d) containment box; (e and f) cobalt blue filter photograph of the OHP sheet used without (e) and with (f) containment box; (g) indirect ophthalmoscopic examination simulation; (h) fundus photography using pediatric camera simulation

a mask to simulate a face shield; the assistant squeezed the bottle to generate some aerosol during the simulated eye examination. The experiment was conducted without and with the acrylic box [Fig. 1c and d]. The OHP sheets were photographed under a cobalt blue filter available with the slit-lamp photography system to detect the fluorescein aerosol on the surface [Fig. 1e and f].

Results

The weight of the box was less than 3 kgs. The entire cost of the transparent 5 mm acrylic sheet (4 feet × 4 feet), fashioned to appropriate sizes, making the desired size holes with acrylic cutter and gluing the cut pieces sheets was under INR 2000. This does not include the cost of our in-house biomedical engineer.

Methods to use the box

The couch is sanitized before the baby is made to lie supine. The mother is encouraged to make the baby lie down on the couch. The box is kept over the baby by the healthcare personnel after donning PPE. The baby's eye examination is done using hand holes, the assistant stabilizes the baby's head from the other side of the box [Fig. 1g]. After examination, the baby is kept inside the box for 10 min to allow the aerosol to settle down before the box is removed by the assistant, and the mother is asked to take the baby from the couch. The couch and the box (inside and outside) are sanitized immediately.

In the simulation, to know the efficacy of the box, the baby mannequin was examined with and without the containment box using fluorescein dye as an aerosol. The OHP sheet, secured on the ophthalmologist's face, when examined under cobalt blue filter showed fluorescein dye when the experiment was done without using the containment box [Fig. 1e].

The "virus" containment box is also useful for fundus photography and laser procedure [Fig. 1h]. We suggest that one allows 10 min before removing the containment box over the baby after the examination. This allows the aerosol to settle down. The box must be sanitized with currently available sanitizers (such as alcohol or viricidal chemicals) before another use. The baby gets enough oxygen through the hand holes, and additional oxygen can be supplemented through single-use oxygen tubes, passed through small side holes [Fig 1b].

Discussion

The risk of ROP-related blindness is increasing globally as more preterm babies survive today with improved neonatal services.[12-14] India has a high number of premature deliveries, and there is a robust national plan for improved neonatal care.[15,16] There is no ROP at birth, it appears after some time (around 1 month), there is a narrow window period during which we can screen and revere the eye condition.[17] Sight-threatening ROP needs to be treated within 48–72 h of detection to avoid irreversible loss of vision in a few weeks after birth.[17] It has been reported that during the COVID-19 pandemic lesser number of babies are getting screened, and this has led to advanced stages of the disease at presentation.[18] The containment box idea was derived from the incubator hood, slanting walls of which give adequate exposure during newborn fundus examination.[19]

ROP is categorized as an emergency care service during the COVID-19 pandemic.[9] The screening of the baby is done under topical anesthesia in a conscious baby. All neonates cry while screening, and the bigger babies are irritable[12] though pacifiers (dextrose wick, honey nipple) may help to some extent. It is not possible to make the baby wear a mask during retina examination; this increases the risk of aerosol transmission to the immediate surroundings and the healthcare workers. Routine reverse transcriptase-polymerase chain reaction (RT-PCR) for COVID-19 is not currently done for all babies seeking ROP screening or laser procedure. Thus, one does not know the corona virus infection status of these babies. Therefore, maintaining universal precautions is required. Our design, a less expensive containment box, is a definite protective device and can be used for examining the eyes of small babies, including ROP. Intraocular pressure using an eyelid tonometer can also be performed using this box to allow the instruments to pass through the hand holes.

The viral load is high in the upper respiratory tract, and it can stay in the air as an aerosol for an hour.[20] Currently, it is believed to be transmitted through droplet infection and direct surface contact.[3] Aerosols are generated if a baby cries during any examination or procedure[21] though we do not know the

quantity of aerosol. PPE is very much required for the healthcare workers during ROP screening since the mask alone may not help prevent disease transmission completely. Thus, an extra barrier of protection is needed in an aerosol-generating procedure.[22]

The virus containment box is relatively inexpensive, lightweight, and portable, and can be carried to various places like the outpatient examination room, operation room, and children's hospital for ROP screening and laser treatment. The box can be sanitized with routine sanitizers such as alcohol or virucidal chemical agents (quaternary ammonium compound used as a surface disinfectant). It can be made ready for subsequent use. Other than ROP, this box can be used to examine the anterior segment of the eye, such as lid, cornea, and cataract, when such are planned without general anesthesia, the baby under the box gets enough oxygen through hand holes during the examination. The box has two small holes (around 5 mm in diameter) at the lower part of the width-wall of the box on either side through which oxygen tube can pass. If the baby is fragile and needs oxygen then and it can reach up to the baby's face/nostril, after ROP screening/laser, the oxygen tube can be discarded.

The simulator used to detect aerosol generation was an approximation of ROP screening and may not represent a real-world scenario. In a real-world system, the aerosol coming out from a crying baby may fly in different directions depending upon the amount of secretion in airways, vector forces on each particle, humidity, and airflow conditions in the external environment. We could not precisely simulate this scenario.

Conclusion

ROP screening and laser delivery procedure is a high-risk procedure in terms of aerosol generation volume and subsequent risk to the healthcare personnel. The new device that could be assembled with little expertise can contain the virus inside the box and allow safe procedures in ROP babies. It can be used in an outpatient setting where neonatal incubator facilities are not available. In the future, this box may be connected to an oxygen cylinder with a filter and an exhaust valve where exhaled air can come outside through a filter. Another modification could be an external tube attachment to remove the exhaled air from the box, which can be connected to high efficacy particulate air (HEPA) filter in an operation room settings.

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Conflicts of interest

There are no conflicts of interest.

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