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Original Research Article

Neonatal Safety Cabinet: A Clinical Apparatus that Reduces Chances of Nosocomial Infections in Neonates

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Abstract

Introduction: Neonates are more prone to get infections in two cases, either by the natal or intrapartum transmission of microorganisms from mother to infant derived from the maternal birth canal. It's quite difficult to reduce the chances of infection at the time of parturition but we will be able to reduce chances after delivery with the help of this specialized cabinet.

Neonates which are hospitalized within the NICU are more susceptible to acquiring nosocomial infections easily. They may acquire these by coming in direct contact with the infected person or also can be infected by inanimate sources which have infected pathogens.

The basic principle to develop this cabinet has arrived from Biosafety cabinets which are generally used in laboratories to maintain aseptic conditions.

Aim: The Goal of this Cabinet is to reduce the chances of nosocomial infections which generally occur in neonates by exposure to the environment of the neonatal or clinical wards.

Material and Method: The cabinet is designed in such a way that it is easy to handle and safe to use for neonates. UV light for self-sterilization of the inner surface of the cabinet. A sensor for UV light is also fitted so that, neonates will not get any exposure to UV even accidentally also. The sensor and buzzers with give an immediate alert. Visible light is used to monitor babies' movement so that they will be under observation. Fans and exhausts are used to avoid suffocation in the cabinet, this also helps to maintain temperature and normal atmospheric pressure as that is in the ward. Various sensors detect power cut-offs. Oxygen cylinders are used to provide additional oxygen supply. For a sterility check-up, the settled plate technique was used. Nutrient agar was used to grow microbial colonies.

Result: The temperature and pressure were found to be the same as that of the environment because of the complete aeration and exhaust system of the cabinet. It was also found safe to be used for neonates. The actual motive was to maintain a sterile environment inside the cabinet that was successfully studied with the help of microbial analysis. Inside and outside cabinet air

microflora was studied by the settle plate technique. The results are as per the observation table which indicates that the total count of colonies by settle plate technique was 78 outside the cabinet (inside the ward) and 21 inside the cabinet respectively. In this way, it was found that this cabinet successfully reduced the chances of infection by 73.1%.

Conclusion: By using the settle plate technique we examined the microflora inside and outside of the cabinet to evaluate the sterility as well as safety regarding harmful microbes. It was observed that with the help of this Cabinet, we are able to reduce the chances of infection by 60-70% which is also with this prototype model which means we can succeed in preventing nosocomial infections by up to 90% with the help of a well-established cabinet.

Keywords: Nosocomial Infection, Prophylaxis, Neonates, Sterility, Safety, Mobility.

Introduction

Premature infants in neonatal intensive care unit (NICUs) are exposed to airborne viable bacteria in indoor environments in NICU which has a highly vulnerable and solitary patient population, various bacterial diversity-causing microbes such as *streptococcus* species, *staphylococcus* species, *Enterobacteriaceae* which may lead to cause Nosocomial infection as infants having poorly developed immunity leading to death [1,2].

As a result of medical technology advancements over the past few decades, neonates, particularly those born with extreme prematurity or congenital defects, are now more likely to survive and have a better quality of life. However, these new born are still at high risk for developing nosocomial infections.

Studies have demonstrated that nosocomial infections can survive in inanimate hospital settings for months and that contaminated rooms are a substantial risk factor for infection. The pathogenic germs may come from a variety of sources such as patients in the hospital, surfaces, or equipment [3,4].

Table 1: Common chances of infections in neonates

Disease or infection	Causative agent	Group
Encephalitis, Meningitis, Neonatal Herpes, and in immunocompromised patients, disseminated infection.	Herpes Simplex	Viruses
Mononucleosis	Cytomegalovirus	Viruses
Polio	Poliovirus	Viruses
Bronchiolitis	Respiratory syncytial Virus	Viruses
Flu	Influenza Virus	Viruses
Common cold	Rhino Virus	Viruses
Listeriosis	Listeria monocytogenes	Bacteria
Abscesses (boils), Furuncles, and Cellulitis.	Staphylococcus aureus	Bacteria
Candidiasis	Candida	Fungus

Considering the situation, we have developed a device titled Neonatal safety cabinet (NSC) which shows the potent ability to control the situation effectively. BSC has multiple applications.

Applications

- An innovative device dealing with the safety of new born after birth in NICU Thus, the cabinet provides a controlled environment.
- This cabinet can also be used to isolate the baby to protect it from viral and bacterial respiratory infections even in the same room where infected family members are present.
- Mobility during intense conditions.
- This safety cabinet has its own disinfectant system from UV radiation thus can be used in a hospital and can be used by other babies too.
- This cabinet facilitates the baby with fresh filtered air and support of oxygen supply to avoid suffocation and oxygen supply to maintain oxygen level in the body. Thus the cabinet provides a controlled environment.
- This cabinet can also be used to isolate the baby to protect it from viral and bacterial respiratory infections even in the same room where infected family members are present.

Materials and Methods

UV light and Visible Light: The reason behind using UV light was to disinfect the area in the cabinet. In the case to use the cabinet by other patients 15 minutes of UV treatment is mandatory and visible light is used to monitor babies' movement in the cabinet.

UV regulator switch: This avoids accidental exposure to UV lights. This sensor facilitates the automatic switch off UV light. This works when some weight (Neonate) is placed inside the cabinet.

Fans and exhausts: These are used to avoid suffocation and to maintain negative pressure throughout the cabinet which facilitates proper aeration.

Additional Oxygen supply: This is to maintain bodies oxygen level in critical conditions. An oxygen cylinder of 1liter capacity is additionally attached to the cabinet.

Hullaards AT21 HEPA Filter: These HEPA filters are placed at appropriate locations to filter the air which avoids microbial entry inside the cabinet.

Mini LCD Digital thermometer sensor: This to monitor the temperature inside the cabinet.

Battery backups: This facilitates current supply during the mobility of the cabinet. We can run this cabinet on AC or DC current supply, the interface is attached to overcome the issue.

Sensors, buzzers, and indicators: These were attached to monitor the current supply and proper working of the instruments attached to the cabinet.

For bacterial examination:

Bacterial examination

The bacterial examination was done using the solid impingement technique along with the settle plate method The first Nutrient rich agar plate was kept in NSC in NICU ward second plate was kept inside the cabinet.

Nutrient Agar

Peptone-1gm, Beef extract-0.33, sodium chloride-0.5gm, Distilled water-100ml, agar-agar-2.5%, Ph-7.0 to 7.2.

Procedure for solid plate impingement technique:

Sterile nutrient agar plates were prepared by dispersing around 15-18ml of sterile nutrient agar into the plates aseptically and allowed to solidify. The solidified plates were labelled properly for the inside cabinet and outside cabinet (in the neonatal ward) microflora. The lead of the Petri plate was opened in the area and the plates were exposed to air for about 1hr. After the exposure time, all the plates were covered with the lid and kept for

incubation at 37℃ for 24 hrs. After incubation, the plates were observed for colony-forming units and the results were recorded by enumerating the CFU in each plate with the help of a colony counter.

Result

Temperature and pressure were normal as that of room conditions. Inside and outside cabinet air microflora was studied by settle plate technique. The results are as per observation table which indicates that the total count on colonies by settle plate technique was 78 outside the cabinet (inside ward) and 21 inside the cabinet respectively.

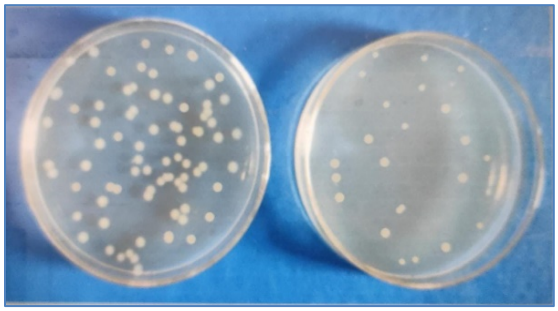


Figure 1: Comparison of Microbial Growth

Observation table

Position of plates	Colonies
Outside Cabinet (Inside ward)	78
Inside Cabinet	21

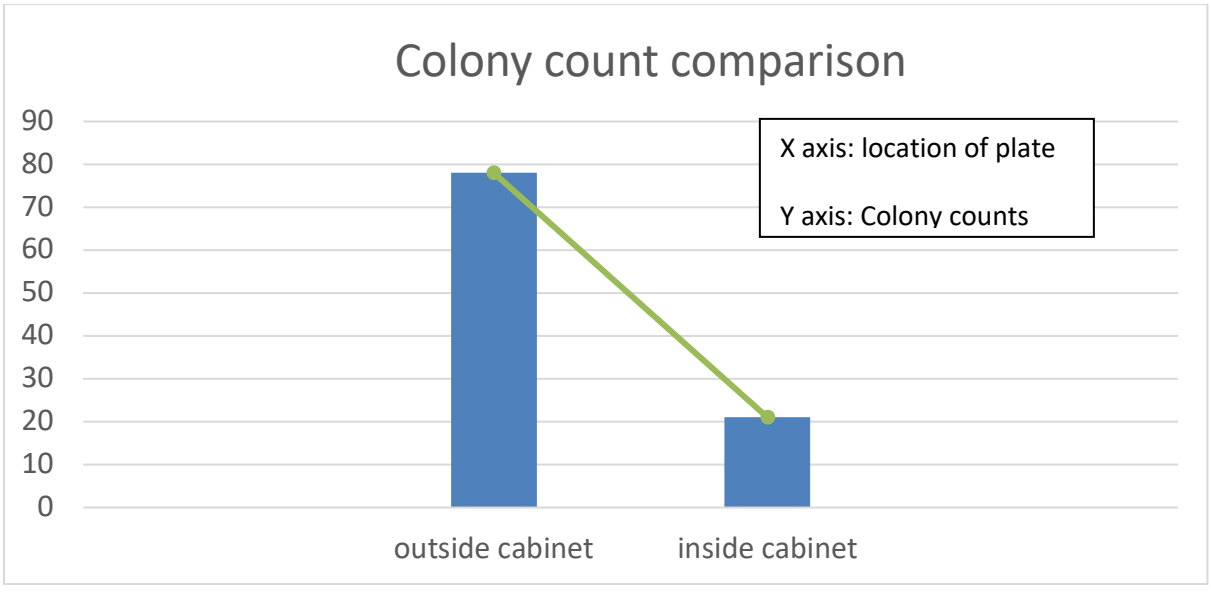
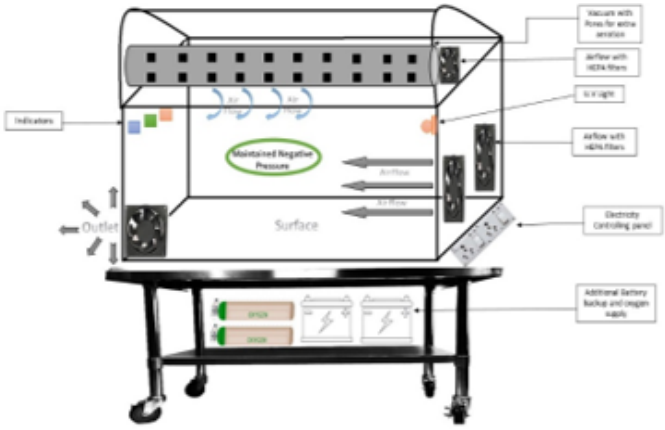


Figure 2: Colony count comparison

Prototype of the cabinet describing workflow:

Supportive data:



Discussion

Cleaning of NICUs is the preliminary and one of the most significant ways of disinfection To maintain sterile-like conditions in NICUs, cleaning with various disinfectants, sterilizing agents, and some other chemicals can be used but even after cleaning microbes such as *staphylococcus* and *streptococcus* can be found [4] (Hewitt, K. M *et al*). These two genera are not only common human commensal bacteria of the skin and mucosal surfaces and have previously been discovered in NICUs, where they are most likely deposited via skin contact, but they also contain species linked to new-born illness outbreaks However, individuals from these two groups also comprise the majority of infectious outbreaks discovered in this NICU between 2011 and 2012, making them crucial cleaning targets. Importantly, the thorough cleaning decreased both the absolute and relative abundance of bacteria on all surfaces that were in contact with infants [5,6]. (Chiguer, M *et al*) (Bokulich, N. A *et al*)

Although NICU staff members offer vital care to their patients, they can occasionally act as a conduit for the spread of infectious diseases. Employees in the NICU should be immune to the flu, measles, rubella, polio, hepatitis B, and measles in order to protect both their own health and that of their patients [7]. (Gastmeier P *et al*). For those who have not developed sufficient immunity via natural disease, vaccines are available. Employees with chickenpox, measles, rubella, herpetic whitlow, and other contagious diseases

should not work in the NICU. Some of the infections that are acquired in the community are more serious. It is well-recognized that RSV, adenovirus, parainfluenza, and influenza can severely infect NICU patients (Kramer, A *et al*)(Stover, B. H *et al*) [8,9].

Some clinical manifestations, such as Sepsis, which is a serious condition brought on by the presence of a harmful bacterium in the blood or other tissue and the body, cause numerous organs to malfunction and may even be fatal. One of the major causes of morbidity and mortality in NICUs, particularly for premature neonates, continues to be Sepsis. Multi-drug-resistant organisms (MDROs) are becoming more and more prevalent as pathogens that contribute to new born Sepsis in NICUs. Bacteria can develop resistance through gene transfer and mutation. The efflux of antibiotics is caused by the efflux pump target being modified by mutation, the hydrolysis of antibiotics, and other processes of antibiotic resistance. (Hota, B *et al*;) (Stover, B. H *et al*) [9,10].

During this study, we have concluded that NSC can potentially minimize the chances of nosocomial infection by the mechanism of biosafety cabinet by maintaining the negative pressure throughout the NSC. According to the previous literature, *Staphylococcus* and *Streptococcus* have previously been discovered in NICUs, they contain species linked to new-born illness outbreaks (Brady, M. T *et al*) [1]. This situation can be controlled by the HEPA filters attached to NSC which prevents the entry of such microbes, fungal spores, pollen grains, dust particles, etc. Even after disinfecting, the surface of NICUs may contain disease-causing microorganisms that may enter NSC through NICUs staff members or by other means. In this scenario, wide exposure to UV light can sterilize the entire cabinet which provides maximum protection to the infants.

To study the microbial diversity in the cabinet and the NICUs the plate impingement method was used, the results show a significant reduction of bacterial colonies as compared to the outer NICUs environment i.e. from 78 colonies to 21 colonies. To increase security and sensitivity the device is equipped with a sensor, buzzers, indicators, mini oxygen cylinder, battery backups, UV lights, and their regulators, weight sensors, and temperature monitoring sensor.

Conclusion

With the help of the settle plate technique, we examined the microflora inside and outside of the cabinet to evaluate the sterility as well as safety regarding harmful microbes. We came to know that with the help of this Cabinet, we are able to reduce the chances of infection by 60-70% that is also with the help of the prototype model which means we can succeed in preventing nosocomial infections up to 90% with the help of well-established cabinet.

Future aspects of the overall study

This device can also be used for breastfeeding, which can be facilitated by a small opening for the entry of breasts in the cabinet, this will reduce the chances of infection through the breast's skin and close contact with the mother. One portal will help to provide entry of hands within the protective covering of the cabinet. But this kind of breastfeeding must be allowed only in emergency conditions such as if the mother is in a highly Viraemic or bacteriome stage.
Further advanced additional pieces of equipment can also be attached which may enhance the monitoring of the neonate's health.

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