Neonatal Skin-Care and Flammability of Neonate Topical Products

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Neonatal skin maturation requires the proper development of the dermis, epidermis and the outermost, semipermeable barrier provided by the stratum corneum. The stratum corneum becomes fully keratinized in uterus between 32 and 34 weeks gestational age. Premature neonates are frequently delivered with severely underdeveloped stratum corneum and epidermal skin layers. The delay in tissue maturation disallows the numerous protective functions provided by fully developed skin.

The Evidence-Based Clinical Practice Guideline for neonatal skin care recommends 2-4 weeks of skin care product application in order to prevent excessive transepidermal water loss (e-TEWL) in preterm neonates delivered prior to 32 weeks gestation. The Association of Women’s Health, Obstetric and Neonatal Nurses (AWHONN) and the National Association of Neonatal Nurses (NANN) have validated the Guideline. Currently, the AWHONN and the NANN recommend a petrolatum-based skin care product to treat neonatal skin.

Neonatal incubators provide environments enriched with 23-100% oxygen while monitoring humidity, oxygen saturation and inspired oxygen concentration. Premature infants may receive oxygen from low-flow, reservoir, high-flow and enclosure systems. Low-flow systems utilize endotracheal tubes and nasopharyngeal catheters to supply oxygen directly into the neonate’s nasopharynx. Reservoir systems and high-flow systems employ specialized masks that surround the infant’s nose and connect to external oxygen supply tubing. Enclosure systems, or headbox set-ups, utilize oxygen hooded designed to surround the head of the neonate.

Petrolatum-based skin care products are composed of highly flammable hydrocarbons. Petrolatum itself is a semisolid mixture of hydrocarbons obtained by the fractional distillation of petroleum. Hydrocarbon-oxygen mixtures are extremely explosive, especially in confined spaces. Furthermore, endotracheal tubing is composed of highly combustible materials with surprisingly low indices of flammability. This lower index of flammability corresponds to a decreased intensity of heat a material can absorb before being ignited. Numerous medical centers have reported fires involving oxygen-enriched environments, endotracheal tubing and confined spaces.

Utilizing advanced silicone creams instead of petrolatum-based products diminishes risks associated with flammability. Silicones are currently used in numerous transdermal delivery systems, catheters and specialized medical devices. A substantial advantage of using silicone over petrolatum-based products for neonatal skin care is silicone’s oxygen compatibility. Silicone-based products that have undergone compatibility testing for use in high oxygen environments have attained promising results. In addition, the industry standard was found to be five times more combustible than selected silicone-based skin care products.

References
Topical Products and Fire Safety in Neonate High Oxygen Environments

Abstract

Skin care product selection may be essential to improving fire safety in oxygen-enriched, neonatal environments. Independent studies were conducted comparing the oxygen compatibility of the industry standard, Aquaphor Healing Ointment® from Beiersdorf AG, was more than five times greater than silicone-based Nutrashield™ and Skin Repair Cream™ from Medline Industries Aquaphor® had a heat of combustion value of 10869 calories/gram, ranking near gasoline at 10400 cal/g and mineral oil at 10930 cal/g. Subsequently, Skin Repair Cream™ and Nutrashield™ received an Acceptability Index rating approximately 20 times and 25 times better than Aquaphor®, respectively. The application of flammable, petrolatum-based products in neonatal intensive care environments enriched with 23-100% oxygen may impose significant risks associated with ignition and fire. Further studies are recommended to determine which products can provide proper neonatal skin care while maintaining fire safety standards.

Background

Table I. Enclosure systems combine oxygen to obtain the oxygen saturation required for infant survival. The system provides an enriched oxygen atmosphere with an oxygen concentration most commonly between 23-90%, although the system is capable of achieving concentrations of 100%. Application of petrolatum-based products containing highly flammable hydrocarbons may endanger infants being treated in confined neonatal enclosure systems.

Table II. Two of the most common endotracheal tube materials are polyvinylchloride and red rubber. Both materials have surprisingly low indices of flammability. The low indices in conjunction with petrolatum-based product application may impose significant risks in neonatal intensive care units. Endotracheal tubes are utilized in low-flow, high-flow and reservoir systems.

Results

Table III. Autogenous ignition temperature indicates a substance’s propensity for ignition; oxygen index indicates a substance’s flammability; heat of combustion is an absolute value of a material’s energy release upon burning. Oxygen compatible Nutrashield™ and Skin Repair Cream™ maintain a high autogenous ignition temperature and oxygen index, and a low heat of combustion.

Discussion

The application of petrolatum-based products to neonatal skin in oxygen-enriched environments may impose significant fire risks. However, introducing highly ignitable and extremely flammable petrolatum materials into infant care systems is avoidable. New silicone technologies allow for oxygen compatible products that provide proper neonatal skin care while diminishing risks associated with fire safety. Each of the following components is considered necessary for combustion to occur under standard conditions. Reducing or eliminating one or more of the components may diminish fire risks:

- Presence of burnable material (petrolatum, etc.)
- Source of ignition (electrical systems, etc.)
- Oxygen

Conclusions

The heat of combustion value of the petrolatum-based product tested was more than five times greater than the silicone-based products tested. The petrolatum-based product had a heat of combustion value of 10869 calories/gram, ranking in between gasoline (10400 cal/g) and mineral oil (10930 cal/g). However, the manufacturer of the chosen petrolatum-based product may indeed offer an alternative skin care product that is oxygen compatible. The silicone-based products tested were determined to be highly compatible with oxygen-enriched environments. The chosen silicone-based products achieved Acceptability Index Values of 1282 and 1023, respectively. Additional studies are recommended to determine which products can provide proper neonatal skin care while maintaining strict fire safety standards.

Figure I. The Acceptability Index is used to rank oxygen compatibility based on the following equation: \[
\text{Acceptability Index} = \left( \frac{\text{oxygen index}}{\text{autogenous ignition temperature}} \right) \times \left( \frac{\text{heat of combustion}}{10000} \right)
\]

Figure II. Heat of combustion is an absolute value of a material’s energy release upon burning, which is an indication of its damage potential. Petrolatum-based Aquaphor® was found to have a heat of combustion greater than gasoline. Furthermore, Aquaphor® contains mineral oil, which was also found to release more energy upon burning than gasoline.
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Endotracheal tube combustion

References