The science behind the light

Introduction

Neonatal jaundice is the most common problem encountered in the newborn nursery. Approximately 60% of all infants will develop visible jaundice during the first week of life. Approximately 8% of all newborns require treatment to cure the hyperbilirubinemia that is causing the jaundice. Phototherapy has been the standard of care for the treatment of neonatal jaundice for over four decades.

The effectiveness of phototherapy is dependent upon four major factors:

- Spectrum/color of the light
- Intensity of the light
- Exposed body surface area
- Duration of exposure

Based on the science of bilirubin degradation and how different types of lights play a role in this breakdown, Natus has developed several phototherapy lights utilizing high-intensity blue light emitting diodes (LEDs). The following is a discussion of factors affecting bilirubin degradation with narrative on how Natus LED Phototherapy Systems meet these challenges.

Spectrum/color

Bilirubin is a yellow pigment with a peak absorption wavelength of 458 nm. Blue light in the narrow wavelength band of 450-475 nm is the most closely matched and hence the most effective type of light in degrading bilirubin.

By utilizing blue LEDs, Natus phototherapy systems emit light within the 450-475 nm spectrum for optimal bilirubin degradation with minimal infrared or ultraviolet light.

Intensity

Intensity refers to the dose of phototherapy or "irradiance." The irradiance determines the effectiveness of treatment – the higher the dosage, the more effective the treatment. Intensity, measured as microwatts per square centimeter per nanometer ($\mu W/cm^2/nm$), is dependent upon the power of the light source and its distance from the infant.

The American Academy of Pediatrics (AAP) defines "intensive phototherapy" as irradiance in the blue spectrum (wavelengths of about 430-490 nm) of at least 30 $\mu W/cm^2/nm$[1] (delivered to as much of the infant's skin as possible).

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The distance of the light source from the infant greatly affects the spectral irradiance. The intensity of the light source is inversely related to the distance from the infant. Heat-producing lights are limited in that they cannot be placed close to the infant without incurring the risk of thermal injury. Thermal-neutral lights, such as LEDs, can be placed to provide intensive phototherapy while reducing the potential risk of thermal injury or fluid loss.

Photometers measure the irradiance of phototherapy systems by taking a single measurement across a band of wavelengths. Photometer responses may vary across different model types and manufacturers. Consequently, irradiance measurements from the same phototherapy system, using different photometers, can produce significantly different numerical results. Natus uses the neoBLUE® Radiometer to measure the spectral irradiance of all its LED phototherapy systems.

Exposed surface area

Effective treatment is dependent on exposing as much of the infant's surface area to phototherapy as possible. The greater the area exposed, the greater the efficacy of phototherapy. Although peak intensity, typically in the center of the light, may be considered "intensive", it may not represent the intensity to the infant's entire body.

When using spotlights, multiple devices may be necessary to ensure proper surface area coverage. When using banks of lights, caregivers must ensure that the intensity delivered to the entire surface area is within the effective intensity range. The international standards governing phototherapy systems, EN 60601-2-50, states that peripheral intensity must equal or exceed 40% of the peak intensity. When measuring the irradiance, caregivers should take measurements at multiple points along the treatment area to verify that their device meets these standards.

Natus has designed each of its LED phototherapy lights to provide a uniform irradiance across the effective treatment area. Other light sources and configurations may not be as effective.

Duration

Increased duration of treatment will translate into an increased response. More effective phototherapy treatments will degrade bilirubin to safe levels faster resulting in shorter treatment times. More effective phototherapy will yield a greater response over a given time interval for better results, especially with dangerously high bilirubin levels.

Additional considerations

Other concerns in administering phototherapy include reducing the potential for insensible water loss and the risk of skin damage. The use of blue LEDs minimizes these risks, as they do not emit significant infrared or ultraviolet light.

Phototherapy systems should be designed for use in a variety of care settings. Natus has designed its lights to use with incubators, radiant warmers and/or open bassinets.

References

1 Subcommittee on Hyperbilirubinemia. American Academy of Pediatrics clinical practice guideline: Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics. 2004; 114(1):297-316.

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