Light Therapy for Neonatal Jaundice [1]

By: Bradley, Arianna Keywords: Phototherapy [2] Light Therapy [3] Neonatal Jaundice [4]

Light therapy, also called phototherapy, exposes infants with jaundice [5], a yellowing of the skin and eyes, to artificial or natural light to break down the buildup of bilirubin pigment in the blood. Bilirubin is an orange to red pigment produced when red blood cells break down, which causes infants to turn into a yellowish color. Small amounts of bilirubin in the blood are normal, but when there is an accumulation of excess bilirubin pigment, the body deposits the excess bilirubin in the layer of fat beneath the skin. That accumulation of bilirubin causes the skin and the white areas of the eye to appear yellowed, a common symptom of jaundice [5]. Buildup of bilirubin typically occurs when the immature liver of a newborn infant is unable to efficiently breakdown the bilirubin molecule into products that the body can excrete. High levels of bilirubin, a phenomenon called hyperbilirubinemia can be toxic and can lead to a brain dysfunction called kernicterus, which may result in permanent brain damage. The relative simplicity of phototherapy treatment has made effective neonatal jaundice [5] treatment nearly universal, almost completely eliminating the risk of infant brain damage from hyperbilirubinemia.

Prior to phototherapy, doctors used exchange transfusion to treat jaundice [5] caused by an overabundance of bilirubin. Exchange transfusion slowly removes blood from an infant's body and simultaneously replaces that with donor blood given through the infant's umbilical cord [6] vein. The process lasts for about four hours and can replace up to twice the total blood volume of the infant. Doctors generally use light therapy rather than exchange transfusion to treat hyperbilirubinemia because the procedure is simpler than exchange transfusion and achieves the same result. However, in cases of extreme hyperbilirubinemia, phototherapy is insufficient to effectively break up the excess bilirubin in the blood, and doctors instead use exchange transfusion.

Sister Jean Ward of the Premature Unit of the Rochford General Hospital in Essex, England noted the benefit of phototherapy in 1956 when she took infants outside because she assumed that fresh air had healing benefits. In areas exposed to outdoor light, she and other doctors noted that the yellow tint of jaundice [5] began to disappear. The staff of the hospital also found that bilirubin levels decreased in vials of blood set in the sunlight. Richard Cremer, a physician at Rochford General Hospital, created the first phototherapy machine to explore the effects of artificial light on premature infants. In 1958, Cremer published "Influence of Light on the Hyperbilirubinemia of Infants," which documented the effects of natural sunlight and artificial sunlight on lowering bilirubin levels in infants.

In 1958, Cremer created the original phototherapy machine as a portable light reflector positioned under the infant's bed. Cremer modeled a hemispherical apparatus that contained eight 24-inch light blue 40-Watt fluorescent bulbs that were evenly spaced apart. Cremer then tested his phototherapy machine by treating eleven infants with periodic phototherapy. Infants received six hours of light exposure from Cremer's phototherapy machine followed by a two-hour break. The treatment resulted in a significant decrease in the infants' blood bilirubin levels. Of the eleven infants that Cremer treated with phototherapy, nine had sufficiently reduced bilirubin levels and exchange transfusion was not needed.

After Cremer published his results, phototherapy did not become widely adopted to treat neonatal jaundice [5] in the United States until a decade later. In 1968, Jerold Lucey, a physician at the University of Vermont College of Medicine in Burlington, Vermont, demonstrated the effectiveness of phototherapy treatment using a randomized, controlled trial. Lucey addressed the concerns of other physicians regarding the potential toxicity of the newly broken down photochemical substances in the blood, advocating for its safety as a treatment for jaundice [5] in infants. Lucey's study helped promote the adoption of phototherapy treatment forjaundice [5] caused by hyperbilirubinemia.

Since Cremer's original phototherapy machine, researchers have modified the model. Modern phototherapy machines use halogen bulbs, light emitting diodes (LED), fluorescent lights, or a combination of all three in addition to blankets that contain fiber optics to increase skin exposure to light. Combination lights are most effective because they deliver the intensity of halogen spotlights, while the use of LED lights cuts down on the excessive heat generated during a session. A nurse handles all infants being prepared for treatment. Before treatment can begin, the nurse must place the infant in the proper position to maximize light intensity on the skin. A nurse also places protection over the infant's eyes to avoid damage and monitors the infant's temperature and hydration levels throughout treatment. The nurse checks the bilirubin levels in the bloodstream after the first four to six hours of treatment by removing a small amount of blood for testing. The lights must be turned off when blood is drawn because otherwise the lights can affect the bilirubin in the blood sample and provide false results.

There are multiple factors in the administration of phototherapy that influence the effectiveness of the treatment of jaundice [5]. Those factors include dosage, light intensity, distance of the infant from the light source, and how much body area is exposed during treatment. The optimal light wavelength range for jaundice [5] treatment is blue light from about 400 nanometers to 520 nanometers. In that range, the orange to red bilirubin is able to absorb the maximum amount of light and break down. Also, the higher the light intensity, the faster bilirubin levels decline in the bloodstream. To increase light intensity, the distance between the infant and the apparatus must decrease. Finally, the greater the surface area of the body exposed during treatment, the more efficient phototherapy is at breaking down bilirubin in the blood.

The most common side effects of phototherapy are loose and frequent stools, dehydration, skin rash, and a grayish-brown skin discoloration called bronze baby syndrome. In low birth weight premature infants, those side effects may contribute to the development of conditions such as chronic lung disease, retinal damage, and a disruption in the small intestine. However, they are all very rare side effects of phototherapy treatment, even for low birth weight infants.

After Lucey published his study in 1968, there was still some doubt amongst those who did not consider bilirubin the cause of brain damage from kernicterus. Gerard Odell, a physician at Johns Hopkins Hospital in Baltimore, Maryland, who studied kernicterus, advocated for the use of the salicylate displacement test with exchange transfusion, which indirectly measured the levels of bilirubin in the bloodstream, to treat jaundice [5] rather than using phototherapy. Odell noted that the liver can effectively break down bilirubin, if it is attached to another compound in the blood called albumin. He argued that the cause of brain damage due to kernicterus was the bilirubin in the blood not attached to albumin. The salicylate displacement test later became less practiced and exchange transfusion became widely adopted in the treatment of infants with extremely elevated levels of bilirubin.

Sources

1. Cremer, Richard J., P. W. Perryman, and D. H. Richards. "Influence of Light on the Hyperbilirubinemia of Infants." *The Lancet* 271 (1958): 1094–7. http://www.sciencedirect.com/science/article/pii/S014067365891849X [7] (Accessed April 7, 2016).
2. Ennever, John Fisher, Anthony Francis McDonagh, and William T. Speck. "Phototherapy for neonatal jaundice [5]: Optimal wavelengths of light." *The Journal of Pediatrics* 103 (1983): 295–9. http://www.sciencedirect.com/science/article/pii/S0022347683803709 [8] (Accessed April 7, 2016).
3. Jospe, Nicholas. "Neonatal Hyperbilirubinemia." The Merck Manual: Professional Edition. http://www.merckmanuals.com/ professional/pediatrics/ metabolic_electrolyte_and_toxic_disorders_in_neonates/ neonatal_hyperbilirubinemia.html. [9] (Accessed April 7, 2016).
4. Lucey, Jerold, Mario Ferreiro, and Jean Hewitt. "Prevention of hyperbilirubinemia of prematurity by phototherapy." *Pediatrics* (Evanston) 41 (1968): 1047–54. http://pediatrics.aappublications.org/content/pediatrics/41/6/1047. full.pdf [10] (Accessed April 7, 2016).
5. Maisels, Michael Jeffrey. "Phototherapy — Traditional and Nontraditional." *Journal of Perinatology* 21 (2001): S93–S97. http://www.nature.com/jp/journal/v21/n1s/pdf/7210642a.pdf?origin= publication_detail [11] (Accessed April 7, 2016).)

6. Odell, Gerard B., GN Bruce Storey, and Leon A. Rosenberg. "Studies in kernicterus: III. The saturation of serum proteins with bilirubin during neonatal life and its relationship to brain damage at five years." *The Journal of Pediatrics* 76 (1970): 12–21. http://www.sciencedirect.com/science/article/pii/S002234767080124X [12] (Accessed April 7, 2016).
7. Porter, Meredith L., and Beth L. Dennis. "Hyperbilirubinemia in the term newborn." *American Family Physician* 65 (2002): 599–607. http://www.aafp.org/afp/2002/0215/p599.pdf [13] (Accessed April 7, 2016).
8. Stokowski, Laura A. "Fundamentals of Phototherapy for Neonatal Jaundice." *Advances in Neonatal Care* 6 (2006): 303–12.
9. Weiss, Elliot Mark, and Zimmerman, Sol S. "A Tale of Two Hospitals: The Evolution of Phototherapy Treatment for Neonatal Jaundice." *Pediatrics* 131 (2013): 1032–34. http://pediatrics.aappublications.org/content/pediatrics/131/6/1032. full.pdf [14] (Accessed April 7, 2016).

Light therapy, also called phototherapy, exposes infants with jaundice, a yellowing of the skin and eyes, to artificial or natural light to break down the buildup of bilirubin pigment in the blood. Bilirubin is an orange to red pigment produced when red blood cells break down, which causes infants to turn into a yellowish color. Small amounts of bilirubin in the blood are normal, but when there is an accumulation of excess bilirubin pigment, the body deposits the excess bilirubin in the layer of fat beneath the skin. That accumulation of bilirubin causes the skin and the white areas of the eye to appear yellowed, a common symptom of jaundice. Buildup of bilirubin typically occurs when the immature liver of a newborn infant is unable to efficiently breakdown the bilirubin molecule into products that the body can excrete. High levels of bilirubin, a phenomenon called hyperbilirubinemia can be toxic and can lead to a brain dysfunction called kernicterus, which may result in permanent brain damage. The relative simplicity of phototherapy treatment has made effective neonatal jaundice treatment nearly universal, almost completely eliminating the risk of infant brain damage from hyperbilirubinemia.

Subject
Phototherapy [15] Jaundice [16] Kernicterus [17] Bilirubin [18] Hyperbilirubinemia [19] Jaundice, Neonatal [20] Lucey, Jerold F. [21] University of Vermont. College of Medicine [22]

Topic
Technologies [23]

Publisher
Arizona State University. School of Life Sciences. Center for Biology and Society. Embryo Project Encyclopedia.

Rights

Format
Articles [24]

Last Modified
Wednesday, July 4, 2018 - 04:40

DC Date Accessioned
Thursday, August 17, 2017 - 22:10

DC Date Available
Thursday, August 17, 2017 - 22:10

DC Date Created
2017-08-17

DC Date Created Standard
Thursday, August 17, 2017 - 07:00

- Contact Us

- The Embryo Project at Arizona State University, 1711 South Rural Road, Tempe Arizona 85287, United States

---

Links
[1] https://embryo.asu.edu/pages/light-therapy-neonatal-jaundice
[2] https://embryo.asu.edu/keywords/phototherapy
[3] https://embryo.asu.edu/keywords/light-therapy
[4] https://embryo.asu.edu/keywords/neonatal-jaundice
[5] https://embryo.asu.edu/search?text=jaundice
[6] https://embryo.asu.edu/search?text=umbilical%20cord
[7]
	http://www.sciencedirect.com/science/article/pii/S014067365891849X
[8] http://www.sciencedirect.com/science/article/pii/
	S0022347683803709
[9] http://www.merckmanuals.com/professional/pediatrics/
	metabolic_electrolyte_and_toxic_disorders_in_neonates/
	neonatal_hyperbilirubinemia.html.
[10] http://pediatrics.aappublications.org/content/pediatrics/41/6/
	1047.full.pdf
[11] http://www.nature.com/jp/journal/v21/n1s/pdf/7210642a.pdf?
	origin=publication_detail
[12] http://www.sciencedirect.com/science/article/pii/
	S002234767080124X
[13] http://www.aafp.org/afp/2002/0215/p599.pdf
	
[14] http://pediatrics.aappublications.org/content/pediatrics/131/6
	/1032.full.pdf
[15] https://embryo.asu.edu/library-congress-subject-headings/phototherapy
[16] https://embryo.asu.edu/library-congress-subject-headings/jaundice
[17] https://embryo.asu.edu/library-congress-subject-headings/kernicterus
[18] https://embryo.asu.edu/library-congress-subject-headings/bilirubin
[19] https://embryo.asu.edu/library-congress-subject-headings/hyperbilirubinemia
[20] https://embryo.asu.edu/library-congress-subject-headings/jaundice-neonatal

[21] https://embryo.asu.edu/library-congress-subject-headings/lucey-jerold-f
[22] https://embryo.asu.edu/library-congress-subject-headings/university-vermont-college-medicine
[23] https://embryo.asu.edu/topics/technologies
[24] https://embryo.asu.edu/formats/articles