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Phototherapy: white light versus blue light in the treatment of neonatal jaundice

Fototerapia: luz branca versus luz azul no tratamento da icterícia neonatal

Fototerapia: luz blanca versus luz azul en el tratamiento de la ictericia neonatal

RESUMO
Objetivo: Analisar as evidências científicas acerca das características e efeitos da fototerapia no tratamento imediato da icterícia neonatal. Método: Revisão bibliográfica onde foram utilizadas 20 publicações científicas das bases de dados LILACS, MedLine, BDENF e SciELO com recorte temporal de 1996 a 2020. A seleção dos artigos foi realizada nos meses de julho e agosto de 2021 através dos critérios de inclusão selecionados para este estudo. Para a análise descritiva dos resultados, foram preenchidos uma tabela comparativa sobre a fototerapia. Resultados: As evidências demonstraram que é importante avaliar criteriosamente o seu uso, principalmente em recém-nascidos, devido a imaturidade completa de seus sistemas, seu uso indiscriminado deve ser revisto, evitando a realização de sessões de fototerapia em casos que a bilirrubina ainda não tenha atingido os níveis recomendados pelos órgãos de saúde responsáveis. Conclusão: A fototerapia tem eficácia na degradação de bilirrubina sérica evitando complicações neonatais.
DESCRITORES: Icterícia Neonatal; Fototerapia; Enfermagem, Bilirrubina

ABSTRACT
Objective: To analyze scientific evidence about the characteristics and effects of phototherapy in the immediate treatment of neonatal jaundice. Method: Literature review using 20 scientific publications from LILACS, MedLine, BDENF and SciELO databases with a time frame from 1996 to 2020. The selection of articles was carried out in July and August 2021 using the inclusion criteria selected for this study. For a descriptive analysis of the results, a comparative table on phototherapy was completed. Results: Evidence showed that it is important to carefully evaluate its use, especially in newborns, due to the complete immaturity of its systems, its indiscriminate use should be reviewed, avoiding the completion of phototherapy in cases where bilirubin does not yet have reached the levels recommended by the responsible health agencies. Conclusion: Phototherapy is effective in the degradation of serum bilirubin, preventing neonatal complications.
DESCRIPTORS: Neonatal Icterus; Phototherapy; Nursing; Bilirubin

RESUMEN
Objetivo: Analizar la evidencia científica sobre las características y efectos de la fototerapia en el tratamiento inmediato de la ictericia neonatal. Método: Revisión de la literatura a partir de 20 publicaciones científicas de las bases de datos LILACS, MedLine, BDENF y SciELO con un período de tiempo de 1996 a 2020. Para un análisis descriptivo de los resultados, se completó una tabla comparativa sobre fototerapia. Resultados: Evidencia que demuestra que es importante evaluar cuidadosamente su uso, especialmente en recién nacidos, debido a la completa inmadurez de sus sistemas, se debe revisar su uso indiscriminado, evitando completar la fototerapia en los casos en que la bilirrubina aún no haya alcanzado los niveles. recomendado por las agencias sanitarias responsables. Conclusión: la fototerapia es eficaz en la degradación de la bilirrubina sérica, previniendo las complicaciones neonatales.
DESCRIPTORES: Ictericia neonatal; Fototerapia; Enfermería; Bilirrubina

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INTRODUCTION

Jaundice is caused by an increase in the concentration of bilirubin in the bloodstream, as hyperbilirubinemia is impregnated in all body tissues, especially the sclera and the skin, which are evidenced with a yellowish or greenish-yellow coloration, because of its signs already become noticeable when its serum level exceeds 2,5mg/dl. 1

However, neonatal jaundice is highlighted due to its frequency of involvement in newborns, that is, approximately 60% of full-term newborns (NBs) are affected by this disease and 80% in preterm infants. After all, in this group it is commonly possible to find serum levels exceeding 5 mg/dl in the first days of life. This increase in bilirubin occurs due to increased destruction of red blood cells and reduced capacity of liver functions, this fact causes a series of changes in the newborn's body. 2

Hyperbilirubinemia can be aggravated when it affects energy metabolism and cell death, after all, through this characteristic, the substance travels through the bloodstream and can cross the blood-brain barrier and permeate the brain and adjacent region, causing severe damage to the brain and irreversible neurological damage. 3

Among the factors involved in neonatal jaundice are hemolytic disorders, deficiency in the enzyme Glucose-6-phosphate dehydrogenase (G6PD), congenital infection, non-spherocytic hemolytic anemia, septicemia, polycythemia, diabetic mothers, hypothyroidism and prematurity. 4

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Thus, jaundice is a serious disease that requires detailed analysis by health professionals to recognize its current signs and symptoms early, that is, distinguish manifestations to follow with appropriate treatments, in which phototherapy stands out, whose therapeutic response is propagated by the action of light energy that enters the superficial layer of the skin and reaches the focus of peripheral bilirubin, transforming it into water-soluble products that are easily degraded and excreted by the kidneys and liver. 5

Therefore, to carry out phototherapy, white fluorescent lights that provide a low irradiance are often used. However, in clinical practice, blue light lamps have been used, which are more effective than white light due to a higher percentage in the range of propagation wave 400 to 490 nm. However, both present contradictions regarding their clinical use, that is, white light can be attributed to subtherapeutic doses in the treatment and blue light for presenting routine complaints from health teams associated with its use, such as: doctors and nurses. 6

Therefore, phototherapy is the treat-

ment of choice for the entity, after all, bilirubin isomerization with the aim of renal excretion is established as the main mechanism to prevent complications arising from bilirubin uptake, especially encephalopathy. Therefore, in the absence of effective and unsatisfactory liver immaturity, phototherapy starts up based on standardized curves according to chronological age, gestational age, weight and risk factors. 7

Therefore, the effectiveness of phototherapy depends on the spectrum and spectral irradiation of the lights. Therefore, ideal phototherapy devices must have a light emission that satisfies a maximum body surface area in the horizontal plane, be durable, generate no heat, and provide a wavelength and intensity around 460-490 nm ≥ 30 μW / cm2 / nm. 8

Therefore, the most used are fluorescent lamps, which emit intense heat and require the use of eye protectors, in addition to increasing water losses, requiring permanent monitoring of vital functions and temperature. In contrast, newer devices use blue light emitting diodes which produce a greater decrease in serum bilirubin levels due to a narrower wavelength with minimal heat production and low maintenance requirements. 9

Therefore, the search for evidence regarding the use of the most effective type of phototherapeutic light is the focus of this research. Therefore, the guiding question is: In the treatment of neonatal jaundice, which is the best phototherapy: blue light or white light? After all, it elucidates a confrontation of phototherapeutic practices, in order to enable a safer and more concrete use in view of the need for each clinical condition, and its elaboration is justified by the contribution to health professionals. Therefore, the aim of this study is to analyze the scientific evidence about the characteristics and effects of phototherapy in the immediate treatment of neonatal jaundice.

METHOD

A literature review study was carried out, which constitutes an important tool for analyzing evidence in the literature in a broad and systematic way to disseminate the results of the studies, helping to point out problems that can be solved with evidence discovered in other researches.

The construction of this literature review was structured based on the following steps: identification of the theme, formulation of the guiding question; establishment of eligibility criteria; survey of studies in databases; evaluation and critical analysis of selected studies; categorization, evaluation and interpretation of results and presentation of the synthesis in the literature review.

In this perspective, the question that guided this study was elaborated: What is the difference between phototherapy performed with white light versus blue light in the treatment of neonatal jaundice.

The inclusion criteria were original articles in Portuguese and English, available in full, in the Latin American and Caribbean Literature in Health Sciences (LILACS), National Library of Medicine (PubMed) and Scientific Electronic Library Online databases. (SciELO), in the period 1996 to 2020 that addressed the main differences between phototherapy with white light and blue light. Duplicate articles in the databases or those not included in the established period were excluded. The survey took place in July and August 2021 and the Mendeley software was used to manage the references.

RESULTS

Table 1. Summary of selected studies, 2021.

DISCUSSION

Neonatal jaundice or hyperbilirubinemia is one of the most common physical examination findings in healthy or sick newborns. The causes are diverse, and the type of treatment will depend on the serum bilirubin level, presence of blood incompatibility, weight, chronological age and associated comorbidities. 12

Jaundice is characterized by the

Table 1. Summary of selected studies, 2021.

TITLE	POPULATION	INTERVENTION	COMPARISON	RESULTS
Phototherapy: white light versus blue light in the treatment of neonatal jaundice.	Newborns with jaundice.	According to Klieman, 2001, to prevent or treat hyperbilirubinemia, it is necessary to expose the newborn to light. The phototherapy device uses white or blue fluorescent lamps and is capable of being equipped with six to eight white or in association with blue lamps.	Several studies have shown that blue light bulbs produce a faster and more accentuated drop in serum bilirubin levels than that obtained with white fluorescent light. 10 According to Moreira, et.al, 2004, there is resistance to the use of blue light in nurseries because of undesirable effects on professionals such as nausea, vomiting and dizziness. Arone (2003), 11 proposes the combined use of blue and white light with the advantage of minimizing the problems with blue light.	The expectation, with the use of blue or white light, is that the newborn reduces the level of bilirubin.

Source: Author, 2021.

ce in the first week of life, and about 10%

of breastfed babies still persist with such pathology at one month of age. So-called "physiological jaundice" is usually harmless. However, there are pathological causes of jaundice in the newborn, which, although rare, need to be detected. 15

In physiological jaundice, the rate of Indirect Bilirubin (IB) is 6 mg/dl and its appearance can be observed around the third day of life, with a regression of the BI rate to 1 mg/dl in approximately seven days after birth. Treatment usually consists of a daily sunbath for the first week of life. 16

Pathological jaundice consists of higher rates of IB (12 to 13 mg/dl) in the bloodstream and its onset, in NB, occurs within less than 24 hours of life. In this type of jaundice, there is a high plasmatic rate of BI and its persistence for a longer time, being greater than a week in the full-term neonate and more than two weeks in the preterm neonate, in addition to increased rates of IB of 5 mg/dl/day. 18

Therefore, the clinical evaluation of hyperbilirubinemia is analyzed by blood sample of serum levels and also by the verification of its propagation in the skin, after all, its progression is in a cephalocaudal manner. Thus, the Kramer's table is used in clinical practice, which distributes to the affected portions in the newborn in certain zones, such as: face (zone 1 from 4 to 8 mg/dl), umbilical region (zone 2 from 5 to 12 mg/dl) and even knees and elbows (zone 3) which may present indirect bilirubin equal to or greater than 15 mg/dl.18

Phototherapy is the most widely used therapeutic modality worldwide in the treatment of neonatal hyperbilirubinemia caused by increased levels of indirect bilirubin (unconjugated fat-soluble). The efficacy of phototherapy is dependent on the absorption of light photons by bilirubin molecules. The higher the dose of bilirubin, the greater the efficacy of phototherapy. 12

Other factors contribute to efficient phototherapy, including: initial concentration of bilirubin before treatment, body surface exposed to light, dose and emitted irradiance, type of light, intensity and wavelengths of light used. Bilirubin absorbs light most strongly in the blue region of the spectrum near 460 nm wavelength. 19

The basic principle of phototherapy action is the photochemical transformation of the structure of the bilirubin molecule into water-soluble products, capable of renal and hepatic elimination.

The higher the serum concentration of bilirubin, the exposed area and the proximity between the baby and the light source, which is generally kept at 30 cm, the greater the efficacy of phototherapy, where the use of diapers is not indicated during the treatment. Irradiance is directly related to the distance between the light and the newborn. 20

According to IP et al. (2004), 21 newborns with high levels of bilirubin can cause severe and irreversible brain damage. Therefore, diagnosis and treatment are of great importance in this age group. The two main strategies to prevent this damage are phototherapy and exchange transfusion. It is the most frequently used phototherapy, but the choice of treatment will depend on the severity and levels of bilirubin.

Although its treatment is simple, clinical studies show the existence of two major factors that directly influence the effectiveness of the treatment: the spectrum of light emitted and the total dose of light received by the neonate. As a result of these factors, the treatment is ineffective, which impairs the control and diagnosis of the true causes of the disease. 22-23

The basic principle of phototherapy action is the photochemical transformation of the structure of the bilirubin molecule into water-soluble products, capable of renal and hepatic elimination. Only bilirubin that is close to the surface of the skin will be directly altered by light. Two mechanisms have been proposed to explain the action of phototherapy in reducing serum bilirubin levels: photoisomerization and photooxidation. 24

According to Carvalho (2001): [20] Photoisomerization occurs in the extravascular space of the skin, so once irradiated, the bilirubin molecule gives rise to two isomers: the geometric isomer, where it has a faster formation and is reversible, with very slow excretion, and the structural isomer, which presents a slower transformation, but it is irreversible, being easily excreted by bile and urine, being the most important mechanism of bilirubin decrease through phototherapy. Photooxidation appears to have

a small contribution in decreasing serum bilirubin levels. It consists of the oxidation of small molecules, leading to the production of water-soluble complexes that will be eliminated in the urine.

The effective light length for bilirubin isomerization is in the 400-500nm range. This length varies depending on the type of light used. The closer the peak of maximum bilirubin absorption, the greater the photodegradation. Daylight and white fluorescent have a main peak between 550-600 nm, blue light between 425-475 nm, special blue light between 420-480 nm. 5

As the light absorption spectrum by the bilirubin molecule is relatively short (350 to 500 nm), this means that, theoretically, light emitted outside this spectrum would have no role in the photochemical reaction. The irradiance emitted in the range corresponding to the absorption of bilirubin is low. Hence the need to equip phototherapy devices with an adequate number of fluorescent lamps (usually seven to eight). 6

When a phototherapy equipped with white fluorescent lamps is placed 50 cm from the patient, the light energy that reaches the patient is below the minimum (4 mw/cm2/nm) recommended in the literature. 25

Blue light (special blue) was introduced in clinical practice in 1972. They have around 45% more energy in the wave band between 400 and 490 nm than white fluorescent lamps, being considered by some authors as the most effective light sources for use in phototherapy. 6

Several studies have shown that blue light bulbs produce a faster and more accentuated drop in serum bilirubin levels than that obtained with white fluorescent light. 10

However, there is resistance to the use of blue fluorescent light in nurseries because of the undesirable effects associated with it. The medical and nursing staff frequently complain of dizziness, nausea and vomiting after prolonged exposure to this type of light. Another inconvenience is that the exposed NB appears intensely cyanotic. This confuses and makes clinical assessment difficult. 6

White light has been the most used type of light in phototherapy over the years. It is the only type of light whose safety has been tested in a large population of NBs monitored during the first six years of life. 26 The combination of blue and white lights has been used with the advantage of minimizing problems with blue light. 11

According to Carvalho (2001) 20 and Pereira (2009), 27 the indication for phototherapy depends on factors such as type of jaundice, serum bilirubin level, specific characteristics of the NB (term or preterm, birth weight, asphyxia, ecchymosis and gestational age) and the presence of factors that predispose to brain damage.

According to Vieira and his collaborators (2004), 28 there are studies that claim the existence of a table containing serum bilirubin levels indicative of phototherapy, however, there is controversy regarding the weight ranges ranging from 1000g to 2500g to start phototherapy treatment.

Phototherapy is contraindicated in patients with a greater increase in direct bilirubin caused by liver disease or obstruction of the bile ducts, which can lead to the "tan baby" syndrome. 12

The intermittent use of phototherapy has been shown to be more effective than its continuous use. There is no time limit for each session, however, the child often needs to be removed from the system to be breastfed and this rest period between feeds can be used as exposure time. The definitive withdrawal of treatment should be carried out after the NB presents a decrease in the serum level of bilirubin, even after the suspension of phototherapy. 29

Phototherapy treatment can bring changes to the exposed baby, such as diarrhea, dehydration, susceptibility to hyperthermia and hypothermia due to direct exposure to the heat source (light) or lack of heating when in the crib, rashes and erythema, burns, mild hemolysis, thrombocytopenia and retinal damage. 30

According to Oliveira et al. (2011), 31 some care is essential during the application of phototherapy, contributing positively to the care of the newborn, including: eye protection, measurement of radiation, protection of the gonads, temperature assessment, change of position and communication between mother and child.

CONCLUSION

Some factors interfere with the quality of phototherapy treatment, as the efficacy of phototherapy depends on the absorption of light photons by bilirubin molecules in addition to the initial concentration of bilirubin before treatment, body surface exposed to light, dose and emitted irradiance, type of light, intensity and wavelengths of the light used.

In view of the aspects observed in the phototherapeutic treatment, blue light (425 - 475 nm), despite causing some discomfort in the medical and nursing staff, such as dizziness, nausea and vomiting, and in addition to hindering the clinical assessment due to the false cyanotic coloration in NB, it is more effective than white light and sunlight (550 - 600 nm) due to the length of light that is in the range (400 - 500 nm), where the closer to this peak of maximum absorption of bilirubin, the greater the photodegradation.

Bilirubin absorbs light most strongly in the blue region of the spectrum near 460 nm wavelength. Therefore, phototherapy is the most cost-effective measure for the effective and early treatment of neonatal jaundice. In addition, phototherapy with blue light also reduces the chance of the newborn developing health problems, such as: hyperthermia and dehydration.

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