

IRRADIANCE OF PHOTOTHERAPY EQUIPMENT IN MATERNITY WARDS IN MACEIÓ

Anne Laura Costa Ferreira¹
Renata Medeiros do Nascimento²
Regina Célia Sales Santos Veríssimo³

Ferreira ALC, Nascimento RM, Veríssimo RCSS. Irradiance of phototherapy equipment in maternity wards in Maceió. Rev Latino-am Enfermagem 2009 setembro-outubro; 17(5):695-700.

The effectiveness of neonatal hyperbilirubinaemia treatment depends directly on the amount of energy emitted by light (irradiance). This cross-sectional study aimed to determine the irradiance of phototherapy equipment in maternity wards in Maceió, AL, Brazil. All equipment in use in the neonatal units in Maceió was included in the study, totaling 36 devices, except those in maintenance. The measurement of irradiance was carried out with a radiometer. We observed that 72.20% of the equipment presented efficient irradiance and 27.76% were inefficient. The conclusion is that the majority of phototherapy devices are emitting the minimum required irradiance for neonatal jaundice treatment.

DESCRIPTORS: jaundice; phototherapy; infant, newborn; light; radiation measurement

LA IRRADIACIÓN DE LOS APARATOS DE FOTOTERAPIA EN LAS MATERNIDADES DE MACEIÓ

La eficacia del tratamiento de la hiperbilirrubinemia neonatal depende directamente de la cantidad de energía emitida por la luz (irradiación). Este es un estudio transversal que objetivó determinar la irradiación de los aparatos de fototerapia en las maternidades de Maceió. Es un muestreo por censo, ya que incluyó todos los aparatos en uso en las unidades neonatales de Maceió, en el total de treinta y seis aparatos (36), excluyéndose aquellos que estaban en manutención. La medición de la irradiación fue realizada con un radiómetro. Se observó que 72,20% de los aparatos presentaron irradiación eficaz y 27,76% de los aparatos fueron ineficaces. Se concluye que la mayoría de los aparatos de fototerapia está emitiendo la irradiación mínima terapéutica para el tratamiento de la ictericia neonatal.

DESCRIPTORES: ictericia; fototerapia; recién nacido; luz; medición de radiación

IRRADIÂNCIA DOS APARELHOS DE FOTOTERAPIA NAS MATERNIDADES DE MACEIÓ

A eficácia do tratamento da hiperbilirrubinemia neonatal está na dependência direta da quantidade de energia emitida pela luz (irradiância). Este é um estudo transversal que objetivou determinar a irradiância dos aparelhos de fototerapia nas maternidades de Maceió. A amostragem foi censitária, pois incluiu todos os aparelhos em uso nas unidades neonatais de Maceió, no total de trinta e seis aparelhos (36), excluindo-se aqueles que estavam em manutenção. A medição da irradiância foi realizada com um radiômetro. Observou-se que 72,20% dos aparelhos apresentaram eficácia quanto à sua irradiância e 27,76% dos aparelhos foram ineficazes. Concluiu-se que a maioria dos aparelhos de fototerapia está emitindo a irradiância mínima terapêutica para o tratamento da icterícia neonatal.

DESCRIPTORES: icterícia; fototerapia; recém-nascido; luz; medição de radiação

¹RN, e-mail: annelaura1@hotmail.com; ²RN, e-mail: medeiros_renata@hotmail.com; ³Assistant Professor, Universidade Federal de Alagoas, Brazil, e-mail: salesregina@hotmail.com.

INTRODUCTION

Hyperbilirubinaemia is the most frequent pathology in the neonatal period. It is estimated that about 60% of newborns develop serum bilirubin levels above 5 mg/dl and about 25% develop serum bilirubin levels above 7 mg/dl associated to visible jaundice⁽¹⁾. Currently, the most used therapies to control serum-unconjugated hyperbilirubinaemia in the neonatal period include phototherapy and exchange transfusions⁽²⁾. Phototherapy is the most used specific therapy because it is a non-invasive method of high impact that diminishes levels of plasmatic bilirubin, regardless of neonatal maturity, presence or not of hemolysis or degree of cutaneous pigmentation⁽³⁾. These treatment action mechanisms mainly include configurational and structural photoisomerization of the bilirubin molecule with photoisomers compounds, which are excreted through biliary and urinary routes without the need for hepatic conjugation⁽²⁾.

Historically, exchange transfusion was the most used therapy, probably due to inefficient phototherapy, which increases the risk of morbimortality that varied according to the services and neonatologists' experience⁽⁴⁾.

The efficacy of neonatal hyperbilirubinaemia treatment depends directly on the amount of energy emitted by light (irradiance)⁽⁵⁾. Therefore, controlling phototherapy equipment in neonatal units is needed. There is a minimum level of irradiance for each type of equipment. The bilirubin molecule absorbs visible light ranging from 400 and 500nm, with peaks around 460 nm⁽⁵⁾. Irradiance is considered the amount of energy emitted on a certain surface, by its unit of area⁽⁶⁾.

Since phototherapy was discovered, 40 years ago, not only indications for its use have changed considerably as new and more efficient models have been introduced in the market⁽⁷⁾.

Assuming that there is variability in the type of device and light bulb used, the characteristics of each type of device have to be known. The conventional or common phototherapy uses from six to eight white fluorescent bulbs (day light)⁽⁶⁾; some devices already have interspersed blue bulbs, at least two. The minimum irradiance of this device is 4mw/cm²/nm⁽⁵⁻⁸⁾.

In devices with blue bulbs, the length of each wave achieves from 425 to 475nm, with irradiance equal to 22 mw/cm²/nm (composed of 7 blue bulbs). These devices present an irradiance two to three times higher than that observed in devices with white bulbs^(6,8). This kind of bulb is not made in Brazil and its importation is hindered by administrative bureaucracy and high costs⁽⁹⁾.

The Bilispot[®] 006-BP device is another equipment used frequently in hospital units. It consists of a light source with halogen light bulbs, preferably used in premature infants due to the size of the light source⁽⁵⁾. It has irradiance above that emitted by conventional devices. Halogen-tungsten bulbs are used and these emit irradiance in a blue range of 25 to 30mw/cm²/nm and filters for infrared and ultraviolet radiation, however, its distribution is irregular, unlike the conventional, and gives a very high peak in the center⁽¹⁰⁾. Bilispot[®] 006-BP bulbs have to be changed when irradiance is below 10 mw/cm²/nm⁽⁸⁾.

Phototherapy efficacy depends directly on the amount of energy emitted in the wave range correspondent to the absorption of light by the bilirubin molecule, on the wave length (color) and intensity of irradiance (energy) of the used source⁽¹⁾.

The non-observance of technical criteria appropriate for the use of this technology can harm the efficacy of the therapy and the quality of treatment delivered to newborns with jaundice⁽²⁾. The mere act of exposing the newborn to light when phototherapy is initiated does not necessarily imply the delivery of appropriate treatment⁽⁷⁾.

Treating neonatal jaundice also means monitoring the bulbs used in the phototherapy devices, aiming to always keep appropriate irradiance. Knowledge about how light acts and the type of bulb used should be constantly monitored for its application in neonatal hyperbilirubinaemia treatment. The device whose irradiance is not monitored can aggravate the newborns' clinical condition and consequently prolong hospitalization.

Routine irradiance measurement of these devices would ensure the efficacy of phototherapy and therefore reduce newborns' hospitalization, diminishing the risk of hospital-acquired infection. The implementation of a measurement routine can also

favor the identification of the need to change or maintain the device, optimizing the quality of care delivery.

OBJECTIVE

This study aimed to determine the irradiance of phototherapy devices in maternity wards in Maceió, AL, Brazil.

METHOD

This is a cross-sectional and descriptive study with a qualitative approach. The study was carried out between September 2007 and February 2008, when 36 phototherapy devices were evaluated, used in six maternity wards in Maceió, AL, Brazil. This study was not submitted to any Research Ethics Committee because it does not involve human subjects.

The sampling process included the maternities registered in the Unified Health System Database (DATASUS). Among the seven maternities chosen, only one did not authorize the study. The remainder signed the document authorizing the study. The hospitals were clarified about the study objectives and the way data would be collected. Anonymity and access to data were ensured, and it was guaranteed that data would only be used for scientific purposes. Equipments in use in the maternities were included in the study and all those in maintenance were excluded.

The Radiometer/Photometer Fanemã-Mod 620 was used, with reading range fixed between 380 and 530nm (10% points) and peak at 450 nm, calibrated immediately before data collection. It is a simple device, operated with a 9-volt battery. Its reading is done in spectral irradiance ($\text{mw}/\text{cm}^2/\text{nm}$), which is the average irradiance in relation to the breadth of the reading range. The average therapy used was in accordance to each evaluated device. Aware that there is no consensus regarding values that would define phototherapy as efficient⁽⁶⁾, the following spectral averages were used as parameter: for the conventional type, the average was 4 $\text{mw}/\text{cm}^2/\text{nm}$ to 35cm from the newborn; for the Bilispot ® 006-BP type, the used average was 5 to 8 $\text{mw}/\text{cm}^2/\text{nm}$ to

50cm from the newborn and for the Bilitron type, the average of 10 $\text{mw}/\text{cm}^2/\text{nm}$ to 35cm from the newborn.

This study was guided by Fernando Facchini's Proposal of Standardization, which for the evaluation of conventional devices, recommends the measurement of irradiance on the surface of the mat with a sheet of cardboard measuring 34x60cm fixed on the surface. An area of 42x34cm was marked in the center of this sheet, which corresponds to the projection of the phototherapy device, since it is used in transverse position in relation to the incubator. This area was divided in nine rectangles of equal areas and, in the center of each, a part was cut in the form of the radiometer used for the readings. The arithmetic average of these nine portions is considered the average spectral irradiance, which the newborn under treatment is subject to⁽⁶⁾.

To evaluate the Bilispot® 006-BP devices, irradiance was measured with the use of a projected circle, drawn on a cardboard and subdivided in three concentric areas, obtained by the shape of two additional circles of 2.5 and 5 cm of radius, which divide the circle in three areas (A, B, C) of 19.6, 58.9 and 98.2 cm^2 , respectively. In each of these areas, four diametrically opposed points were marked so as to serve as the measurement site of irradiance, which according to the manufacturer itself, reduces considerably from the center to the periphery. Arithmetic averages of these four points, once weighted with their respective areas and summed, provided the spectral average of the energy beam therapy⁽⁶⁾.

$$\text{Total ASI} = \text{ASIA} \times 19.6/176.7 + \text{ASIB} \times 58.9/176.7 + \text{ASIC} \times 98.2/176.7$$

ASIA = average spectral irradiance obtained in the four points of area A

ASIB= average spectral irradiance obtained in the four points of area B

ASIC= average spectral irradiance obtained in the four points of area C

176.7= total area in cm^2 of the circle of light projected by the device⁽⁶⁾.

On the other hand, there was no standardization for the Bilitron devices published in the field. Thus, the study was guided by the manufacture's guidelines according to the used bulb. Reading was done around 30-40 cm in the central region of the super LEDs – central point. Data were stored in an electronic spreadsheet and descriptive

analysis was carried out using the Statistical Package for the Social Sciences (SPSS) version 15.0.

RESULTS

The 36 devices were analyzed in terms of their spectral irradiance, type of device, used bulb and quantity of bulbs by device, in addition to the existence of radiometers in the six studied hospitals.

There was a predominance of Bilispot® 006-BP devices, which is evidenced by its dichroic configuration, in which only 40% of the value accompanies the light beam⁽⁶⁾. The device has irradiance above that emitted by the conventional type, but its distribution is irregular, which diminishes its efficacy in relation to the irradiance value.

Table 1 – Type of phototherapy device by maternity. Maceió, AL, Brazil 2008

Maternity	Type of phototherapy device			Total of devices by maternity (%)
	Bilispot	Biltron	Conventional	
A	10	0	1	11 (30.55)
B	2	2	3	7 (19.44)
C	3	0	3	6 (16.66)
D	1	1	3	5 (13.88)
E	1	2	2	5 (13.88)
F	0	0	2	2 (5.55)
Total	17	5	14	36 (100)

In relation to the type of used bulbs, there was a predominance of tungsten halogen bulbs, characterized by high-emitted irradiance, cooled by a system of forced air circulation to dissipate some of the produced heat. They have a filtering system of undesirable radiations, such as those of the infrared band in phototherapy⁽⁶⁾.

Table 4 – Number of phototherapy related to emitted irradiance and the type of device used in the hospitals in Maceió, AL, Brazil 2008

Measure ($\mu\text{W}/\text{cm}^2/\text{nm}$)	Number of phototherapy x irradiance			
	Conventional white + blue (%)	Conventional white(%)	Biltron(%)	Bilispot(%)
Below 4	8(22.22)	1(2.77)	0(0)	1(2.77)
From 4 to 10	4(11.11)	1(2.77)	4(11.11)	4(11.11)
Above 10	0(0)	0(0)	1(2.77)	12(33.33)
Total	12(33.33)	2(5.55)	5(13.88)	17(47.22)

Table 2 - Number of devices in hospital facilities according to the type of bulb. Maceió, AL, Brazil 2008

Hospital	Device according to the type of bulb			
	White (%)	Blue (%)	Blue and white (%)	Halogen (%)
A	1(2.77)	0(0)	0(0)	10(27.77)
B	0(0)	2(5.55)	3(8.33)	2(5.55)
C	3(8.33)	0(0)	0(0)	03(8.33)
D	0(0)	1(2.77)	3(8.33)	01(2.77)
E	2(5.55)	2(5.55)	0(0)	01(2.77)
F	1(2.77)	0(0)	1(2.77)	0(0)
Total	7(19.44)	5(13.88)	7(19.44)	17(47.22)

The presence of radiometers in the hospitals revealed concern with monitoring the irradiance emitted by these devices and half of the studied hospitals had devices to measure irradiance.

Table 3 – Presence of radiometer by hospital unit. Maceió, AL, Brazil 2008

Hospital	Diameters	Percentage (%)
Have it	3	50
Do not have it	3	50
Total	6	100

Comparing the irradiances in limit parameters of emitted dosage, we verified that 27.76% of the devices emitted irradiance below $4 \text{ mw}/\text{cm}^2/\text{nm}$, which is the irradiance with the least efficacious dose for jaundice treatment by phototherapy^(6,8,11).

We also verified that Bilispot® 006-BP devices (33.33%) presented irradiance above $10 \text{ mw}/\text{cm}^2/\text{nm}$, which is established as fast and efficacious therapy in terms of emitted irradiance.

Adequate bulbs, according to the type of device, directly influence the efficacy of emitted irradiance. Of the studied devices, 8.32% were

inappropriate. In terms of adequate irradiance by type of device, the study showed that, of the 36 studied devices, 38.87% were not efficacious.

Table 5 – Adequacy of irradiance by type of device versus adequacy of bulbs in Maternities in Maceió, AL, Brazil 2008

	Adequacy of irradiance by type of device x adequacy of bulbs							
	Conventional white + blue		Conventional white		Bilitron		Bilispot	
	yes	no	yes	no	yes	no	yes	no
Adequacy of irradiance	3(8.33%)	17(19.44%)	2(5.55%)	2(5.55%)	1(2.77%)	4(11.11%)	16(44.44%)	1(2.77%)
Working bulbs	9(25%)	1(2.77%)	1(2.77%)	2(5.55%)	5(13.88%)	0(0%)	17(47.22%)	0(0%)

DISCUSSION

Phototherapy to treat jaundice has been the main choice for more than 30 years and has been efficient and safe to diminish indices of bilirubin, whose rate of decline is proportional to the emitted light, indicating that, the higher the intensity of phototherapy irradiance, the higher its efficacy⁽⁴⁾. The dosage of phototherapy largely determines how fast bilirubin will return to its normal levels. When intensive phototherapy is used, one can expect it will decrease between 0.5 mg and 1 mg/dl per hour during the first 4-8 hours of therapy. With a standard of irradiance considered efficient, bilirubin decreases from 6 to 20% in the first 24 hours⁽⁴⁾. Therefore, the higher the irradiance emitted by the phototherapy device, the better and faster the therapy will be⁽⁴⁾.

The need to monitor the measurement of the phototherapy devices' irradiance has been described for some time in international literature. In Brazilian literature, some studies address the analysis of irradiance of phototherapy devices in hospitals. The majority of studies are linked to higher education institutions. These studies focus on factors that interfere in treatment efficacy, including exposure of the newborn to light, distance of the newborn from the light, change of decubitus, eye protection and hydration of babies, while the measurement of the devices' irradiance is carried out in a single central point, with distance found above the newborn, directly measuring the irradiance, excluding peripheral exposed areas. These studies also emphasize the need to use blue bulbs to increase the potency of the irradiance, with prevalence of white and blue bulbs. However, the efficacy of the phototherapy does not depend only on color, but also on the irradiance of light⁽¹²⁾.

This study evaluated the irradiance of the device in satisfactory conditions in relation to the distance between the light and the cradle and incubators. The majority of phototherapy devices presented incorrect distances in relation to the newborn and these distances were corrected before starting the measurement so as to avoid that the distance standardization error interfered in the irradiance value. We considered that the irradiance emitted by the device could even be adequate, but that incorrect distances could be inefficaciously dissipating the light.

We also measured all points reflected by light on the newborn, establishing a spectral average according to Facchini's proposal⁽⁶⁾. Irradiance has to be measured in multiple sites below the lighted area, by unit, and the average measurements were calculated because the measurement at the center of the light source can be twice the measurement at the periphery⁽⁴⁾. These strategies allowed us to obtain more reliable data.

An analysis about the irradiance of phototherapy devices was carried out in 2003 in hospitals in Curitiba, PR, Brazil and the conclusion was that almost half of the devices used in the treatment of neonatal jaundice were inefficacious⁽⁹⁾. Another study was carried out in Brasilia, also addressing the irradiance of phototherapy in a teaching hospital, which concluded that the facility needed to arrange for the devices' maintenance and buy new phototherapy equipment⁽¹³⁾.

The phototherapy devices in the maternity wards of Maceió, AL, Brazil presented, in their majority, adequate irradiance for neonatal hyperbilirubinaemia therapy, since 72.20% presented irradiance above 4 mw/cm²/ nm.

Results also show that phototherapy devices are being correctly monitored and that 50% of the maternities possess measurement monitors (radiometers). It shows that the professionals of these maternities are aware of the importance of this equipment and its use, indicating that newborns with jaundice who are receiving phototherapy have great chances of being appropriately treated, since the majority of the maternity wards in Maceió have devices with adequate irradiance. However, treatment efficacy does not depend only on spectral irradiance, but also on the spectrum of emitted light, spectral power in relation to the exposed surface and on the cause of the jaundice⁽⁴⁾. Adequate irradiance of phototherapy devices is only one of the several criteria required for treatment success. In addition, positioning the newborn at the ideal distance for each type of device, exposing the largest possible body surface and the time newborns are exposed to light also interfere in therapy success.

Efficacy of therapy should be assessed in all cases and the level of irradiance should be indicated and recorded. It should also be measured in multiple sites below the lighted area by unit of measurement, because irradiance diminishes as one gets away from the central area⁽⁴⁾.

There is a large number of devices emitting the minimum recommended irradiance value to promote the reduction of serum bilirubin levels. The maintenance of parameters of irradiance and consequent interference of this maintenance in the efficacy of newborns treatment depends directly on a qualified nursing team. Efficient phototherapy diminishes the newborns' time of hospitalization and unnecessary exposure to phototherapy treatment for a prolonged time.

CONCLUSION

This study shows that 72.20% of the phototherapy devices of the maternity wards in Maceió, AL, Brazil present adequate irradiance for neonatal hyperbilirubinaemia treatment with values above 4mw/cm²/nm. However, it is imperative that professionals make possible the inclusion of measurement and maintenance routine of these devices, favoring a higher emission of irradiance.

The expression "not everything that illuminates, treats"⁽¹⁴⁾ translates the importance of checking the irradiance of these devices as well as the maintenance of these bulbs, creating a routine to change and calibrate the radiometer.

REFERENCES

1. Almeida MFB. Quando devemos iniciar a fototerapia em RNPTS? *Jornal de Pediatria* 2004; 80(4):256-8.
2. Kopelman BI, Santos AMN, Goulart AL, Almeida MFB, Miyosh MH, Guinsburg R. Diagnóstico e Tratamento em Neonatologia. In: Almeida MF, Draque CM organizadoras. *Fototerapia*. São Paulo: Atheneu; 2004. p. 343-7.
3. Bueno M, Sacai S, Toma E. Hiperbilirrubinemia Neonatal: Propostas de intervenções de enfermagem. *Acta Paul Enferm* 2003; 16(2):75-83.
4. Martínez JC. El real problema del recién nacido icterico. *Nuevasguías de la Academia Estadounidense de Pediatría/ Arch Argent Pediatr* 2005; 103(6):524-32.
5. Segre AMC. Perinatologia: Fundamentos e Prática. In: Bastos F, organizador. *Ictericias*. São Paulo: Sarvier; 2002. p. 583-600.
6. Facchini F. Proposta de Padronização para aferição de equipamentos de fototerapia. *J Pediatría* 2001; 77(2):67-74.
7. Carvalho M, Lima CLMA, Vieira AA, Moreira MEL. O uso da fototerapia em recém-nascidos: avaliação da prática clínica. *Rev Bras Saúde Matern Infant* 2004; 4(4):359-66.
8. Colvero AP, Colvero MO, Fiori RM. *Fototerapia*. *Scientia Medica* 2005; 15(2)90-5.
9. Kliemann R, Nohama P. Avaliação dos equipamentos de fototerapia no tratamento da hiperbilirrubinemia neonatal em Maternidades de Curitiba. II Congresso Latinoamericano de Ingeniería Biomédica; 23 al 25 maio 2001. La Habana, Cuba.
10. Carvalho M. Recentes Avanços em Fototerapia. Conferência; I Simpósio Internacional de Neonatologia do Rio de Janeiro; 26-28 agosto 1999; SOPERJ; Rio de Janeiro (RJ); Brasil.
11. Correa RC, Tomas NTS. A importância no atendimento de enfermagem em crianças com ictericia neonatal 2000. [Acesso em 10 set 2007]. Disponível em: www.ebah.com.br/download/3411/faculdade/enfermagem/ictericia-neonatal
12. Karagol BS, Erdeve O, Atasay B, Arsan S. Efficacy Of Light Emitting Diode Phototherapy In Comparison To Conventional Phototherapy In Neonatal Jaundice / Ankara Universitesi Tip Fakultese Mecmuasi 2007; 60(1).
13. Secretaria de Saúde do Distrito Federal (BR). Fundação Hospitalar do Distrito Federal. Alto risco em neonatologia no Hospital Materno Infantil de Brasília. *Hiperbilirrubinemia indireta*. Brasília (DF); 2000.
14. Carvalho M, Lopes J, Maria A. Fototerapia nos Hospitais Públicos do Rio de Janeiro: nem tudo que ilumina trata. *J Pediatría*. 1991; 67(5/6):157-62.