Original Article

Using the Visible Blue Light of Argon Laser Technology for Treatment of Jaundice in Infants

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Abstract

Objective: To determine the effect of visible blue wavelengths of argon laser beams in reducing bilirubin levels in newborns with jaundice. **Background:** Newborn jaundice ("hyperbilirubinemia") results from increased bilirubin concentrations in the skin and blood. Sunlight, comprising various light rays, is commonly used to treat this condition by breaking down bilirubin molecules. Other phototherapy techniques, including lamp phototherapy, are also employed. Methods: An experimental study was conducted on six male infants (5 to 15 days old) with jaundice at a hospital. These infants were exposed to blue-violet scattered light from an argon laser with a wavelength of 450 nm. **Results:** The concentration of bilirubin in these infants decreased following exposure to the argon laser light. The 450 nm wavelength effectively absorbs bilirubin, facilitating its breakdown. **Conclusion:** The study demonstrates the effectiveness of using argon laser with visible blue light in reducing bilirubin levels in infants with jaundice. This finding encourages health professionals to consider argon laser therapy as a treatment option for neonatal jaundice.

Keywords: Argon Laser, Emitting Diodes, Wavelength, Blue Light, Bilirubin Pigmentation, Fluorescent, Jaundice, Laser Therapy.

Introduction

In infants, jaundice, also known as hyperbilirubinemia takes place due to the breakdown of liver function. In this regard, erythrocytes' hemolysis is also increased by different causes. Within this context, the Z,Z-bilirubin molecules' concentration is found to be increased a lot as compared to normal values in the skin and blood of the infant. Therefore, different methods are used for treating this condition.[1] One of the most commonly used source for this treatment includes sunlight, followed by lamp phototherapy. Sunlight is a collection of electromagnetic waves; a person can see part of it called visible light and the rest of it is not visible to the naked eye.[2] Ultraviolet rays are invisible, and each type of rays has benefits and harms. These rays are usually used for treating jaundice within infants. At the same time, the blue light emitted by lamps is used in the treatment of jaundice. It is the yellow pigmentation of the skin and whites of the eyes as a result of high levels of the bilirubin pigment in the blood due to the failure of the red blood cells in the body to decompose properly. Blue light also has significant effects on the skin, as it helps the healing process, especially by improving the formation of blood vessels and accelerating the production of new skin through phototherapy. It is a method of treating some diseases by exposure to sunlight or certain wavelengths of light using laser (light-emitting diodes),[3] fluorescent lamps emitting blue light, or dichroic lamps, and this light is usually controlled by the use of certain devices.

Therefore, this study aims to determine the effect of visible blue wavelengths of the argon laser beams in reducing the proportion of bilirubin (jaundice) in newborns. For this purpose, an experimental study has been conducted. The current study has been significant in improving the literature regarding the use of visible blue light of argon laser technology in treating jaundice within infants. This study has also improved the knowledge regarding the utilization of sunlight for treating jaundice within newborns. Therefore, the results obtained from this study can encourage the health professionals to develop and

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implement effective laser technologies for treating jaundice in newborns to protect them from further complications.

Literature Review

Jaundice in Infants

Jaundice is the yellow pigmentation of the skin and whites of the eyes due to elevated levels of the bilirubin pigment in the blood because red blood cells in the body are not broken down properly. Stools may be pale and urine dark in color. More than half of all babies in the first week after birth have jaundice, and in most cases, it is not a serious threat. If the baby's bilirubin levels are too high for a long period of time, they may develop a type of brain damage known as kernicterus.[4] The causes of jaundice range from non-serious to fatal. Serum bilirubin levels are usually less than 12 mg/dL, and levels above 13 mg/dL leads to jaundice. Therefore, it is commonly observed in newborns due to increased serum levels of bilirubin. Bilirubin is a substance that arises when the body destroys red blood cells. Red blood cells usually live 120 days, after which the body breaks them down for a group of compounds, including bilirubin. The compounds then reach the liver via the bloodstream, where the liver breaks them down into bilirubin before excreting it in the bile duct secretions in the intestine,[5] in some cases, the defect may cause the destruction of red cells and the incomplete development of the liver of the infant, causing a defect in the functions of the liver to the accumulation of bilirubin in the liver and the emergence of jaundice.[6]

Treatment of Jaundice in Infants

Different techniques are used for the treatment of jaundice in infants which involve the utilization of different laser therapies as well as phototherapy.

Laser Therapy/Phototherapy

In Photodynamic Therapy, infant is placed in an incubator that contains lamps or lasers that emit blue light rays with wavelengths of (400-500) µm. This light changes the shape of the bilirubin molecules in the child's body and breaks them into a substance that is easily excreted with urine. During the treatment, the child wears eye patches, and only wears a diaper.[6] Laser therapy or phototherapy is a method of treating certain diseases by exposure to sunlight or specific wavelengths of light using lasers, light-emitting diodes, blue-emitting fluorescent lamps, dichroic lamps, or ultraviolet, full-spectrum light. The technology of this light is usually controlled using certain devices, and the patient is exposed to this light for specific periods of time.[7]

In the current studies, laser therapy is performed alone or in combination with other treatments, such as peri- or intralesional injections of autogenic conditioning plasma, platelet-rich plasma (PRP), hyaluronic acid, fat-derived stem cells, tiludronic acid, bionic cells, and shockwave medication or surgical interference (tendovaginoscopy of check ligament, splint bone fasciotomy).[8] This is found to be effective in treating jaundice in infants.

Solar rays are a group of electromagnetic waves; part of which humans can see is called visible light and the rest is not visible to the naked eye. The visible rays of the sun's spectrum are composed of red to violet rays, which are the colors of the rainbow. Infrared rays have a wavelength of 700 nm and ultraviolet rays have a wavelength of 400 nm.[9] Two parts of the sun's spectrum are not visible to the naked eye as shown in Figure 1. The part with a wavelength greater than 700 nm is called the infrared range, and the other part has a wavelength Less than 400 nanometers is called the ultraviolet range.[10]

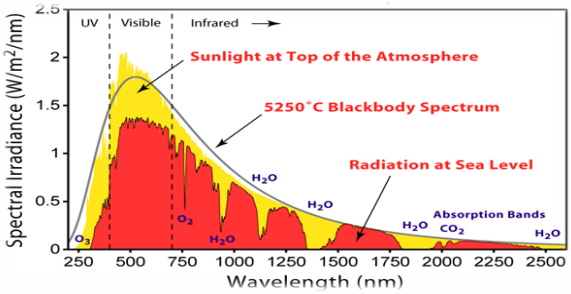

Figure 1: Shows the Spectra of Solar Radiation.

Scientists distinguish three types of rays that make up solar radiation. One of the ray is invisible and is estimated at 50% of the total solar radiation, and its wavelength ranges from (0.7-4) microns, it plays an important role in the whole activity. However light rays, are in fact invisible,[10] while sun's rays penetrate the space without seeing it, but they are scattered in the atmosphere or reflected from the surface of the moon and this scattering is the secret in illuminating the atmosphere with daylight. Its wavelength ranges from (0.4-0.7) microns, and the strength of light rays on the Earth's surface increases at noon during the day in summer. Additionally, ultraviolet rays, are invisible and they account for about (13%) of the total solar radiation, and their wavelength varies from (0.4-0.1) microns.[11]

Visible Light and Wavelength

Part of the spectrum of electromagnetic radiation visible to the human eye, the wavelength of visible light ranges from (400-700) nm, where its colors range from red to yellow, green, blue, then violet and the spectrum of electromagnetic radiation for red (the longest wave) and

the spectrum of electromagnetic radiation for violet (the shortest wave). The wavelengths of different sources of visible light are estimated between the narrow range (420 to 680) nm to the wider range (380 to 800) nm,[12] where the wavelength of blue light ranges from (400-500) nm, as shown in Figure 2. Visible light is emitted and absorbed in small "packets" called photons that can be studied as particles or waves. This property is called wave-particle duality, and in physics the word light is sometimes used for electromagnetic radiation of any wavelength, visible or not.

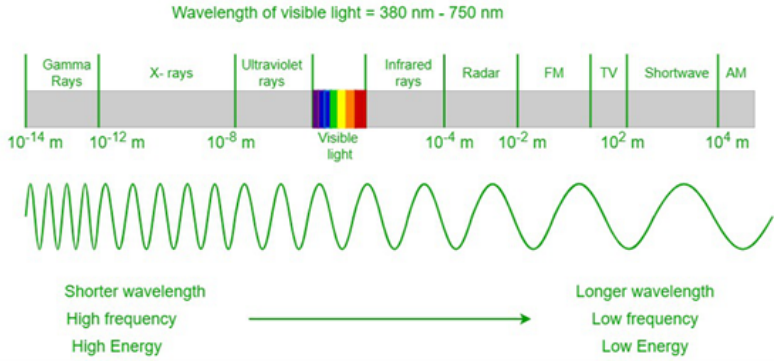

Figure 2: Shows the Spectra of Visible Light.

The wavelength is the distance between similar points between two successive waves and is symbolized by the wavelength λ, expressed by the following equation v/f = λ.[13] There is an inverse relationship between the wavelength of light rays and the amount of energy they contain. Light rays with long wavelengths contain less energy, while rays with shorter wavelengths contain more energy, determining the wavelength of light associated with frequency and energy.[14]

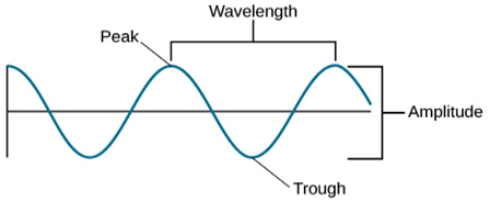

Figure 3: Shows the Wavelength.

Benefits of Laser Blue Light Rays

Sunlight consists of red, orange, yellow, green, and blue light rays, depending on the energy and wavelength of the individual electromagnetic rays. Accordingly, blue light is visible light with a wavelength ranging from (400-500) nm, and the blue light is split into blue-violet light with a wavelength of (400-460) nm and turquoise blue light with a wavelength of (460-500) nm as shown in Figure 4.

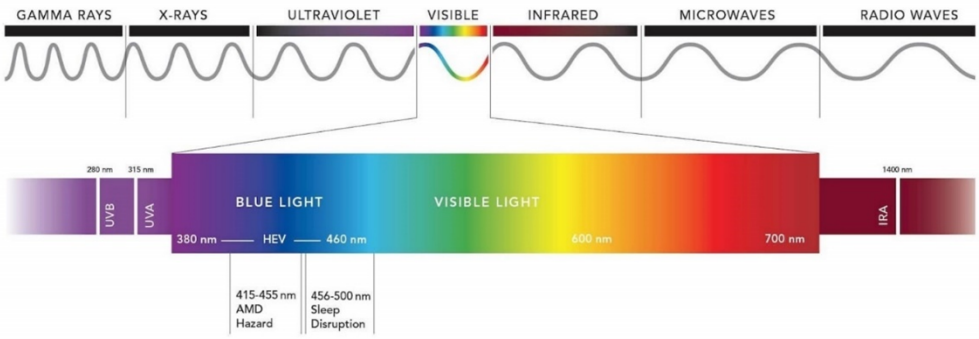

Figure 4: Shows the Spectra of Blue Light Rays.

Past research shows that blue light rays emitted by lasers are used in the treatment of jaundice . They help in the healing process by improving the formation of blood vessels and accelerating the production of new skin.[14] It

has a role in eliminating acne or fungal infections in the skin. Therefore, moderate exposure to blue light during the day raises the mood, activates memory, and regulates the circadian rhythm of the body's wakefulness and sleep cycle. It is used very safely for gum tissue as it does not cause any damage to the hard tooth material. They are used to treat gum disease because they have a bactericidal effect. The main indication of the argon laser is to cure composite resins, making the material much stronger. It is also used to diagnose caries and vascular malformations.[15]

Research Method

Research Approach

In order to determine the effect of visible blue wavelengths of the argon laser beams in reducing the proportion of bilirubin (jaundice) in newborns, an experimental research approach was used. For this purpose, an argon laser with vsible blue light was taken into account.

Study Sample

For this study a sample of six male infants was taken into account. For this purpose, an effective inclusion and exclusion criteria was developed. For instance, no infant with age more than 15 days was included in this study. At the same time, only male infants were included due to easy reachability to their parents. No infant with incomplete medical history was included in this study.

Phototherapy Incubator System

For this study, a phototherapy incubator system was used. It is an incubator with a cylindrical shape, open from the front and back, and consisting of a strong transparent glass cover that contains argon laser bulbs, which emit scattered blue light rays of blue-violet light with a wavelength of (400-500) nm, used to treat the child from jaundice, the device works on an electrical capacity of 18 watts.

The Components of the System

The system presented in Figure 5 was used for this study after making some changes to it and it consists of:

1. Sturdy clear glass lid.
2. Argon laser, which is a diode that emits blue light rays with the use of an optical diffuser to facilitate the scattering of blue-violet light, with a power of 18 watts
3. Thermistor control panel to protect the incubator device.
4. Heater device with a sensitive system to know and control the temperature of the incubator at 37 degrees Celsius.
5. Oxygen device to provide the baby with oxygen inside the incubator.
6. Humidity generating device with a sensitive system to know and control the degree of humidity inside the incubator.
7. Fan to distribute heat, air, moisture and oxygen inside the incubator

Figure 5: Shows the Phototherapy Incubator Device.

Working of the System

1. The infant was placed in the incubator.
2. The eyes and the reproductive system are covered with a dark covering that does not allow blue light rays to pass through them.
3. The device was operated via the Control Panel.
4. Heater temperature was set at 22 degrees and humidity inside the incubator at 50%.
5. The incubator is supplied with oxygen through the oxygen machine.
6. Adjust the Fan to distribute heat, humidity and oxygen inside the incubator.
7. Exposing the child to a laser pulse, with optical diffuser, as the scattered blue light emits blue-violet light with a wavelength of 450nm, and the blue light penetrates the photoelectric cell, causing a light reaction in the child's body inside the incubator.
8. The level of bilirubin in the blood was measured to ensure that it is normal or not, after exposure to phototherapy.

Figure 7: Shows the Exposure of the Child to Blue Light Rays.

Total serum Bilirubin T.S.B. Blood Test for Newborns

1. An amount of blood from the heel of the infant's foot was taken through a Capillary tube containing an anticoagulant, heparin, and the amount of blood in the capillary tube is three quarters of the tube.
2. One end of the capillary tube is closed with an artificial clay.
3. The researcher put the tube in a Micro centrifuge device for 5 minutes at a speed of 5000 revolutions per minute, as the device works to separate the serum from the blood plasma.
4. The blood sample was placed in the incubator of the device, which consists of two holes: the opening for entering the tube and the opening for the serum side to penetrate the rays. The blood sample was placed in the incubator so that the serum is on the side that the rays penetrate to get the correct reading through the light. Then the researcher put the incubator in the Bilirubin device meter which showed the reading of Bilirubin in newborns.
5. If the percentage of Bilirubin in the blood was more than 13 mg, the child will undergo treatment, including phototherapy, Bilirubin, and if the percentage of Bilirubin is less than 12 mg, it was considered a normal percentage in the child's blood.

Data Analysis

After the exposure of the infants to the visible blue light of argon laser, the level of bilirubin in the serum was compared before and after the treatment.

Results

The laboratory results were obtained, where a blue light was used from the optical diffuser of the Argon laser and tests were conducted, and the light of the blue system lamp was used and the same tests were performed on other infants. And we noticed that the value of the Bilirubin was well lower than that of the normal lamp, and as shown in Tables 1 and 2.

Table 1: Shows the Value of the Bilirubin Before and After Exposure to the Rays of a Lamp with Blue Light.

Child's Age in Days	Bilirubin Value (dL) /mg) Before Exposure to Lamp Blue Light	Bilirubin Value (dL) /mg) After Exposure to Blue Light
5 موي	13	10
7 موي	15	11
9 موي	17	12

Table 2: Shows the Value of the Bilirubin Before and After Exposure to the Scattered Argon Laser with Blue Light.

Child's Age in Days	Bilirubin Value (dL) / (Mg Before Exposure to Laser Light	Bilirubin Value (dL) / mg) After Exposure to Laser Light
11 موي	14	9
14 موي	16	10
15 موي	17	11

Discussion

This study mainly focuses on determining the role of argon laser with visible blue light to treat jaundice in infants. For this purpose, six male children with jaundice were taken as samples in the hospital, their ages ranged between (5-15) days, when exposed to blue-violet scattered light from the argon laser with a wavelength of 450nm, a decrease in the percentage of Bilirubin in the blood was observed. The reason for this is that the scattered blue light of the color of the argon laser with a wavelength of 450nm has a high absorbency that absorbs and works to create a photoreaction with the compound Bilirubin, which changes the shape of the Bilirubin molecules in the child's body and breaks them into a substance that is easy for the body to deal with called Lumirubin.[16] Then it runs through the bile duct to the duodenum (small intestine) and then the large intestine to be excreted outside the body with feces and urine, thus reducing the percentage of bilirubin in the body of a child due to the rays of blue light. Past research has also supported the utilization of sunlight for treating jaundice in infants.[17] At the same time, the same time, the role of visible blue light in absorption of bilirubin molecules is also inevitable.[18] Thus, the current study has been effective in this regard.

Conclusion

The blue light beam with a wavelength of 450nm has a

high absorbance that works to absorb and break down the bilirubin compound into an easy soluble molecule in water, so the bilirubin decreases in the child's body better than the lamps blue light wavelengths of (400-490-500) nm of blue light.

Research Implications

The current study has been effective in highlighting the significance of visible blue light of argon laser in treating jaundice in newborns. This study has also been effective in improving the knowledge of the readers regarding the utilization of argon laser and phototherapy for the treatment of jaundice in newborns. At the same time, the current study can also encourage different healthcare professionals to utilize argon laser with visible blue light for the treatment of the jaundice within newborns.

Limitations and Future Research

This study incorporates few limitations. For instance, this study only includes a sample of six infants which limited the study's scope. This was due to the easy accessibility of required data. In addition, this study only used argon laser technology for treating jaundice in infants due to limited resources.

Therefore, in future research a large sample size can be included to test the role of argon laser in treating jaundice. Moreover, other techniques such as sunlight, phototherapy and other associated treatments can be compared with argon laser technology for treating jaundice in infants within future research.

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