

# A Review of Non –Invasive Jaundice detection using Optical Technique in Neonates

<sup>1</sup>Nurashlida Ali ,<sup>2</sup>Siti Zarina Mohd Muji ,<sup>3</sup>Zuhairiah Zainal Abidin

**Abstract**—This paper, introduced a non-invasive jaundice detection using optical technique. Jaundice is a condition when baby skin, eyes and other tissues became yellow. The yellow came from bilirubin pigment that bound with albumin before breakdown. If too many breakdowns of hemoglobin in one time, liver couldn't excreted all bilirubin. For babies, bilirubin will cause brain damage if its too high more than 10mg/dL inside them. It happened when bilirubin became toxic dice and go to the brain that cause death. There are two techniques of detection bilirubin namely invasive technique and non-invasive technique. The differences of this technique are invasive technique was painful then non-invasive technique and it have to take some blood to be analyzed. Both methods used the principle of Lambert law as references and guide to measure bilirubin inside babies.

**Keywords**—Neonatal Jaundice, Wavelength, Bilirubin, Non-invasive.

## I. Introduction

In medical field, optical technique was not odd anymore; there have many equipment that used this technique such as Pulse Oximeter that measure oxygen inside human blood. The principle of absorption using infrared and red LED as light source to determine of oxygen reflection inside blood is called non-invasive technique.

Meanwhile, invasive technique is using blood to determined some disease such as jaundice. Invasive technique have to draw some blood, that cause traumatism and painful for the babies. Jaundice can be identifying by when the skin and eyes are becoming yellow in color. The yellowish of skin came from bilirubin when there have a breakdown product of hemoglobin. For normal baby, bilirubin concentrations will

less than 5mg/dL but if more than 10mg/dL it call hyperbilirubinemia as shown in Fig. 1.

Bilirubin can be classified by unconjugated and conjugated stated. Unconjugate stated when bilirubin can be seen on skin and eyes by determine the color of it. For conjugate stated, the stool will be white chock and urine will be dark than normal baby.

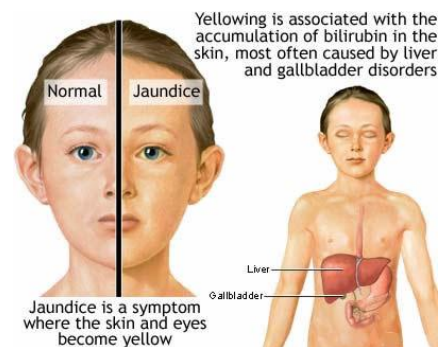


Figure 1. Different of normal and jaundice babies.

In Malaysia almost 60% to 70% newborn will have jaundice problem[1]. The high concentration of bilirubin will became neurotoxic and can cause brain damage or kernicterus[2]. Bilirubin pathway is from the breakdown of heme in red blood cells. The broken down of heme travel to liver, where it been secreted into the bile. The liver function is to filter out the waste such as bilirubin from blood. Here, bilirubin will be unconjugated bilirubin and excreted into stool and urine. The modern English word is jaundice and jaunisse derived from middle French, jaun means “yellow” and –isse means “ness” which means “yellowness”.

Therefore, in this paper, non-invasive technique of bilirubin detector proposed. This non-invasive technique will be less painful, reduce turnaround time and easy to handle. This paper is organized as follows : In Section II, recent research about non-invasive technique detailed . Section III explained the proposed technique. Finally, a conclusion is drawn in Section IV.

## II. Non-Invasive Technique

Several research has been done about non-invasive bilirubin. Gosset was using Ictrometer in 1960[3]. Ictrometer is like transparent ruler that has different mark of yellowish color of skin. Each of mark will have different value to recognize bilirubin level.

Nurashlida Ali

Universiti Tun Hussein Onn Malaysia  
Batu Pahat, Johor, Malaysia

Siti Zarina Mohd Muji

Universiti Tun Hussein Onn Malaysia  
Batu Pahat, Johor, Malaysia

Zuhairiah Zainal Abidin

Universiti Tun Hussein Onn Malaysia  
Batu Pahat, Johor, Malaysia

The yellowish of skin gave Hanneman and Yamanouchi some idea to introduce spectral reflection by using light with different wavelength absorption of bilirubin[4].

The absorption of bilirubin are shown in Fig.2. It shows that the absorption between hemoglobin and bilirubin that attract with certain wavelength are different. When the light in the range between 457nm until 473nm are used, the bilirubin shows the maximum absorption. While for oxyhemoglobin, it shows the maximum absorption between 527nm until 532nm[5].

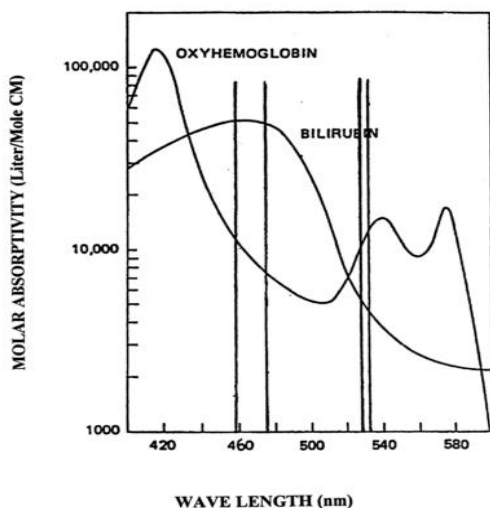


Figure 2. Absorption of spectral light for hemoglobin and bilirubin at 457,473,527 and 532nm.

By referring Fig. 3, the range of 455 to 492 nm is a blue color meanwhile 492 to 577 nm is a green color[6]. Hemoglobin will absorb less blue color compare with bilirubin. Therefore, in this research , the blue light become the light source to determine the bilirubin level, meanwhile green light as references to determine the difference between bilirubin and hemoglobin[7].

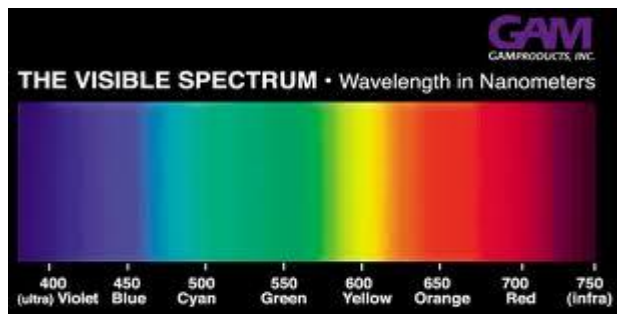


Figure 3. Electromagnetic Spectrum of Visible light.

The recent research of jaundice blood was done by Jayasingh and Sankaranarayanan[8].The research was using the RGB Color Sensor to detect the jaundice level. For Srinivas Kudavelly et.al, their research based on wavelength

of light[9]. However these researches need a blood to be taken by injection and not using non-invasive technique.

### III. The Proposed Technique

Using icetrometer and reflection spectrometer technique, user could not make a continues monitoring. Ictrometer was not user friendly because it have to read manually and predict using color of mark to read the value of concentration bilirubin. Gosset’s research, shows that the result 20-40% reproducibility which is less sensitive and specification based on measurement of reflectance [10].

Spectrophotometric reflection technique by Hanneman and Yamanouchi shows that their technique was difficult to handle and still could not measure continues monitoring bilirubin inside newborn. Therefore, some modification to the exist system should be done to add a continuous monitoring to make sure all the data captured can be used as a source of information for the further investigation in the medical research.

Spectrophotometric make used of Lambert Law to determine absorption and concentration concept of bilirubin as shown in Fig. 4. This concept has been use in reflection of spectrometer when the light output is less than light input [11]. It happens as the bilirubin absorb a certain wavelength of light and make the output become lesser. The absorption, A, can be calculated using Equation 1.

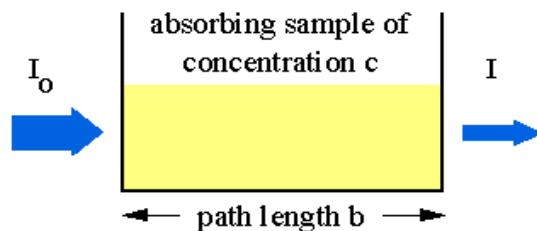


Figure 4: Lambert law of absorption light.

$$\text{Absorption, } A, = \log_{10} \frac{I_0}{I} \quad (1)$$

$I_0$  = incident light intensity  
 $I$  = transmitted light intensity

The wavelength absorption shows that green and blue LED can detect bilirubin concentration. There also have specific place to take measurement that effect bilirubin concentration. Forehead and sternum is best location to get bilirubin concentration[10]. Blue and green LED are the suitable light source to determine bilirubin and haemoglobin inside newborn as shown in Fig. 5.

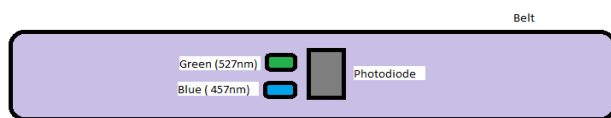


Figure 5. Blue and Green LED are the light source for bilirubin and heamoglobin.

Both light source will interact with bilirubin and heamoglobin and the reflected light will be absorbed by photodiode. Photodiode will determine the reflection of light to alert the user if the bilirubin value was at the above normal condition. The technique of detection the bilirubin using noninvasive method will be a less painful and userfriendly.

#### iv. Conclusion

In conclusion , the non-invasive bilirubin detection using optical technique is a better solution to eliminate the baby trauma in the process of jaundice detection. The purpose of this project is to improve and adapt methodology of continues diagnostic for newborn and accuracy of early detection bilirubin. The automated systems enable detection of sensor, measurement concentration bilirubin and alarm for home monitoring.

#### Acknowledgment

This research was supported by FRGS with Vot 1209. We thank our Universiti Tun Hussein Onn Malaysia who provided insight and expertise that greatly assisted the research, and Dr. Siti Zarina Mohd Muji for comments that greatly improved the paper.

#### References

- [1] S. Z. Sahib, "Ibu tak perlu risau," 28.02.2012 2012.
- [2] K. Grohmann, M. Roser, B. Rolinski, I. Kadow, C. Müller, A. Goerlach-Graw, *et al.*, "Bilirubin measurement for neonates: comparison of 9 frequently used methods," *Pediatrics*, vol. 117, pp. 1174-1183, 2006.
- [3] Ü. Akman, I. Arikan, H. L. Bülgen, S. Kala., And E. ...Zek, "Transcutaneous Measurement of Bilirubin by Ictrometer During Phototherapy on a Bilibed," 2001.
- [4] M. Hamza, "Laser transcutaneous bilirubin meter:a new device for bilirubin monitoring in neonatal jaundice," in *SPIE Proceedings*, 1988.
- [5] Mostafa Hamza, Ahmad Mohammad Hamza, and M. H. S. El-Ahl, "Blue green diode pumped solid state laser system for transcutaneous bilirubinometry in neonatal jaundice," in *Proceedings of SPIE*, 2001.
- [6] A. Al-Azzawi, *Light and Optics: Principles and Practices*: Taylor & Francis, 2006.
- [7] M. William Oh, "Phototherapy -A Review," presented at the FDA, 2003.
- [8] R. Jayasingh and K. Sankaranarayanan, "A Novel Colorimetric Detection Method for Jaundice using RGB Color Sensor " *European Journal of Scientific Research*, vol. 91, pp. 563-568, 2012.
- [9] S. Kudavelly, P. Keswarpu, and S. Balakrishnan, "A Simple and accurate method for estimating bilirubin from blood," in *Instrumentation and Measurement Technology Conference (I2MTC), IEEE*, 2011, pp. 1-4.

- [10] M. Kajabová, "Determination newborn bilirubin POCT techniques," 2011.
- [11] J. Chaves, *Introduction to Nonimaging Optics*: Taylor & Francis, 2008.



**Nurashlida Ali** was born Batu Pahat, Johor, Malaysia, in 1989. She received the D.Eng.Tech and B.Eng.Tech in Medical Electronic from Universiti Kuala Lumpur British Malaysia Institute, Selangor, Malaysia, in 2010 and 2013. She is currently pursuing her Masters by Research Degree in Electrical Engineering from Universiti Tun Hussein Onn Malaysia, Johor, Malaysia. Her research interest include in medical electronic devices and measurement.



**Siti Zarina Mohd Muji** received the B.Eng. in Electrical Engineering from Universiti Sains Malaysia in 2001, M.Eng from Universiti Sains Malaysia in 2004 and Ph.D degree from Universiti Teknologi Malaysia, Johor, Malaysia. She was a Lecturer at Universiti Tun Hussein Onn Malaysia, Johor, Malaysia since 2004.



**Zuhairiah Zainal Abidin** was born in Kuala Lumpur, Malaysia, in 1978. She received the B.Eng.in Electrical and Electronic Engineering from Universiti Teknologi Malaysia, Johor, Malaysia, in 2001, the M.Eng. in Electrical Engineering from Kolej Universiti Teknologi Tun Hussein Onn, Malaysia, in 2003, and Ph.D. degree from the School of Engineering, Design and Technology, Bradford University, West Yorkshire, U.K in 2011. She is a Senior Lecturer at Universiti Tun Hussein Onn Malaysia since 2004. She has authored or coauthored several refereed journal articles and international conference papers. Her current research interests include MIMO antenna design, electromagnetic bandgap (EBG), defected ground structures (DGS), and neutralizations techniques for wireless and mobile systems.