Jurnal Teknologi

Full paper

Jaundice Assessement of Newborn Baby: A Short Review on Kramel's Rule and Magnetic Induction Spectroscopy

Zulkarnay Zakaria[a,b], Jurimah Abd Jalil[b*], Shazwani Sarkawi[a,b], Ibrahim Balkhis[a,b], Mohamad Aliff Abd Rahim[a,b], Nazahah Mustafa[a,b], Maliki Ibrahim[a,b], Mohd Hafiz Fazalul Rahiman[a,b], Ruzairi Abdul Rahim[c]

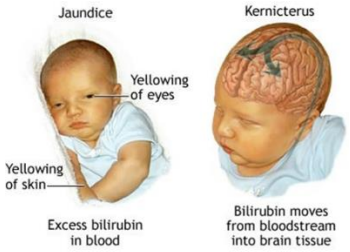
[a]*Tomography Imaging Research Group, School of Mechatronic Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia*
[b]*Biomedical Electronic Engineering, School of Mechatronic Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia*
[c]*Process Tomography and Instrumentation Engineering Research Group (PROTOM-i), Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310, UTM Johor Bahru, Johor, Malaysia*

*Corresponding author: zulkarnay@unimap.edu.my

Article history

Received : 15 August 2014
Received in revised form :
5 January 2015
Accepted : 10 February 2015

Graphical abstract



Abstract

Jaundice is a yellow discolouration of white eyes (sclera), skin and mucous membrane which is clinically apparent when the level of serum bilirubin rises up to 5 mg/dl. Jaundice could cause abnormalities in the newborn infant when production of bilirubin exceeds the normal range. Formation of bilirubin starts from degradation of hemoglobin and haemoprotein, which is released from red blood cell. Current technique in evaluating jaundice of new born infant is based on Kramer's Rule but unfortunately it is not very applicable to the babies with dark skin. Thus Magnetic Induction Spectroscopy (MIS) is introduced as an alternative to this issue as MIS is a non-invasive, non-intrusive and electrodeless measurement scheme. This paper will go through short overview on jaundice measurement as well as MIS modality.

Keywords: Bilirubin; magnetic induction spectroscopy; Kramer's rule

1.0 INTRODUCTION

Jaundice is yellow discolouration of white eyes (sclera), skin and mucous membrane [1] and a common problem that need to be faced by every newborn infant during the first week of life[2]. Abnormalities of bilirubin formation in metabolism, transportation in blood and excretion can lead to neonatal jaundice. When serum bilirubin keeps increasing, it can cause unconjugated bilirubin then enters the nerve cells and kills cells that leads to brain damage which is known as kernicture[3,4]. In order to determine total serum bilirubin in newborn infants, invasive technique is used to acquire blood sample from babies. It is a common technique used by the medical staffs in department of pediatric and neonatal intensive care unit (NICU) to assess neonatal jaundice[3]. Certain volume of blood samples are taken from newborn infants for bilirubin level analysis. Unfortunately, this conventional technique is causing trauma and discomfort for both the babies and parents. Hence, the babies are exposed to skin infection due to small cuts on their skins. Figure 1 shows skin and eyes of a baby that is yellowing due to excess amount of bilirubin in the blood. When the excess bilirubin moves from the bloodstream to brain tissue it could cause kerniture to the baby.

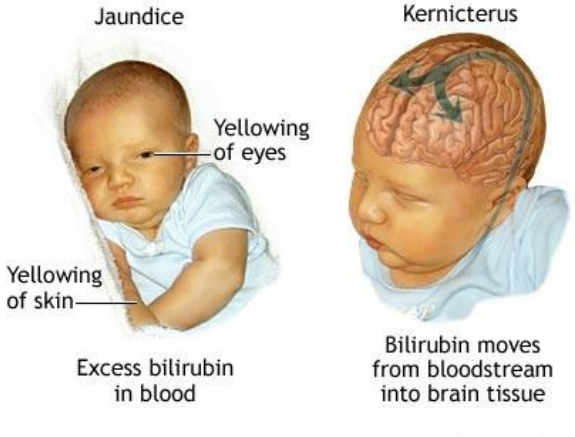


Figure 1 Jaundice in newborn infant

2.0 LITERATURE REVIEW

2.1 Bilirubin

Bilirubin is one of the bile pigments[5] in human body and it is a tetrapyrrolic yellowish pigment compound in blood serum[6,7] and a water-soluble which require enzyme-mediated glucuronidation in the liver for biliary excretion[8]. Production of bilirubin is originated from degradation of heamoglobin and other haemoproteins where 75 % to 80 % of it is structured and discharged from red blood cell[1,8,9]. Figure 2 describes formation of bilirubin where degradation of heamoglobin is active in spleen and bone marrow is associated with element of bilirubin formation.

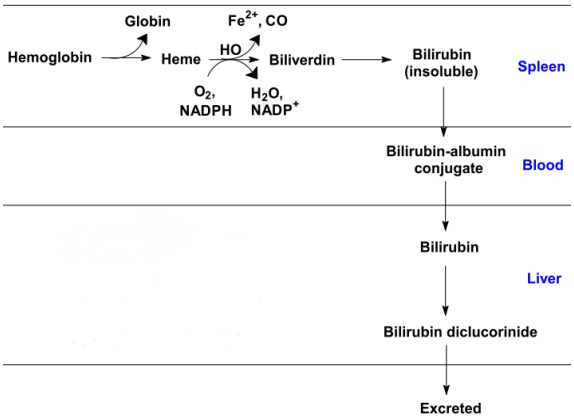


Figure 2 Overview of bilirubin formation[5]

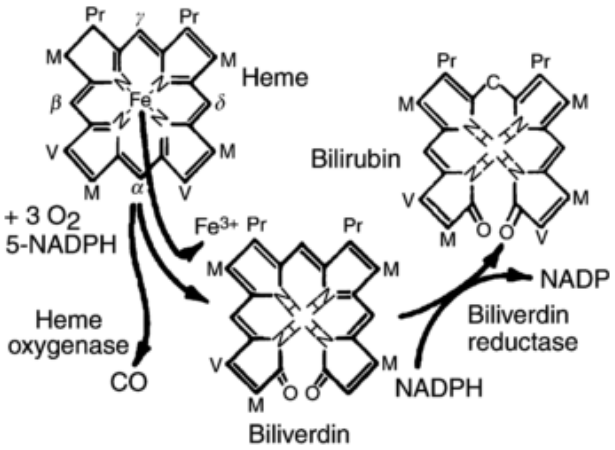


Figure 3 Bilirubin formation[10]

Bilirubin is likely to be toxic to newborn infant and possibly can lead babies to suffer irreversible brain damage. Production of bilirubin starts from releasing of heme[11] which degraded in human body and associated to the heme oxygenase (HO)[5,6] where this element changes over heme to biliverdin IX. In this regard, biliverdin represent hydrophilic compound which act as biliverdin reductase into hydrophobic compound bilirubin. After that, heme ring is opened by heme oxygenase (HO) catalase an oxidase because to converts one of the bridge carbons to carbon monoxide. Thus, iron is discharged from the linear tetrapyrrole yielding biliverdin. Finally, enzyme of biliverdin reductase will reduce the double bond on nitrogen which inside one of four of the pyrrole rings then prompt to development of bilirubin[5] as in Figure 3.

2.2 Jaundice Assessment

Kramer's Rule is one of the technique used to evaluate baby that have experienced in jaundice. Kramer's Rule is similar to visual assessement. Regarding on Kramer's Rule, observation in newborn infant for jaundice begin from head of the baby then broadens towards the feet when the level rises[12–15]. Kramer's Rule comprises of five zone as on Figure 4 which described about cephalocaudal progression of jaundice in term infants. It helps in deciding whether the baby is expected to have the serum bilirubin (SBR) measured or not. Table 1 represents the value of serum bilirubin (SBR).

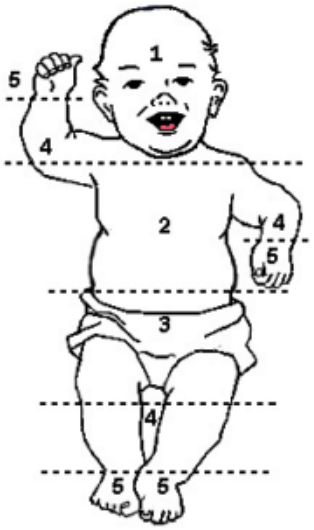


Figure 4 Zones of Kramer's Rule[14]

Table 1 Serum bilirubin (SBR)[14]

Zone	Definition	TSB (micromole/L)
1	Head and neck	100
2	Upper trunk	150
3	Lower trunk and thighs	200
4	Arms and lower legs	250
5	Palms and soles	>250

Unfortunately, Kramer's Rule is not beneficial if the baby have dark skin. Thereby, the blood test need to be taken from the baby's heel onto a blood spot card as shown in Figure 5. Then, the blood spot card is sent to the research facility which is laboratory for testing. To aquire an accurate test result, blood specimens must be gathered when the newborn infant is 48 hours old or at the earliest opportunity after this[16].

Figure 5 Blood sample[16]

2.3 Dielectric of Biological Tissue

Dielectric properties is related to the electricity of the materials. When the voltage is applied to the materials it will conducts electricity poorly. Regarding on research of R. Pethig in 1984,[17] he was disclosed that large dielectric dipersion is emerging at the frequency range that below than 1 kHz as well as in the region between 10 kHz and 100 MHz. At the point when the frequency range is greater than 100 MHz the dielectric properties of the tissue is predominantly determined by the aqueous contents which together with the presents of ions and small molecules in the cellular fluids. Figure 6 represents relative permittivity for a typical biological tissue.

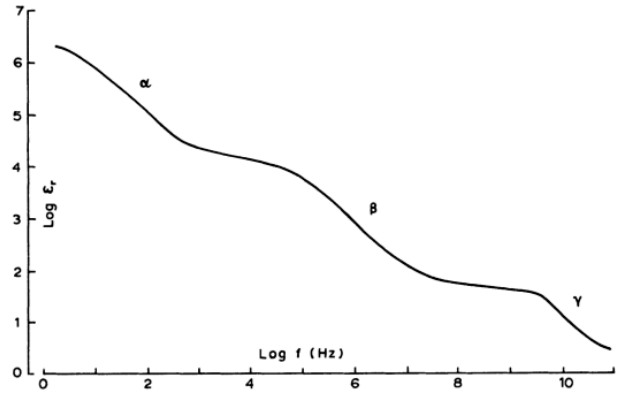


Figure 6 Relative permittivity ε'with frequency for a typical biological tissue[17]

Regarding C. Gabriel *et al.*, 1996[18] who highlighted the relative permittivity of tissue may reach values up to 10^6 or 10^7 when frequency is below 100 Hz. Then, at high frequencies range it decreases in three main steps which are known as α, β and γ dispersions[18,19]. For γ and β dipersions it represents in gigahertz and in the hundred kilohertz region respectively. Gigahertz region is due to polarization of water molecules, while kilohertz region is due to polarization of cellular membranes. The electrical properties of tissue depend on interaction at cellular level. Based on previous researcher, Stuchly (1980) have tabulated data of dielectric properties of tissue in frequency range of 10 kHz to 10 GHz. Low frequency α dispersion is associated with ionic diffusion processes at site of the cellular membrane and the tissue which have finite ionic conductivities is commensurate with nature and extent of their ionic content and ionic mobility[18] .

2.3 Magnetic Induction Spectroscopy

Magnetic induction spectroscopy is highlighted in application of non-invasive jaundice measurement. In magnetic induction spectroscopy principle, a single channel measurement that comprised of transmitter coil (Tx) and receiver coil (Rx) will be simulated and studied. In this field is disclosed about passive electrical field (PEP) which focuses on electrical conductivity, dielectric permittivity and magnetic permeability[20,21]. Besides that, this method will create a varying in time magnetic field which is from an exciting coil, then induce the field to object that under study. Information of the data is obtainable from disturbance or reaction of coils environment system where through receiver coil or sensor coil[21]. Figure 7 represents principle of magnetic induction spectroscopy.

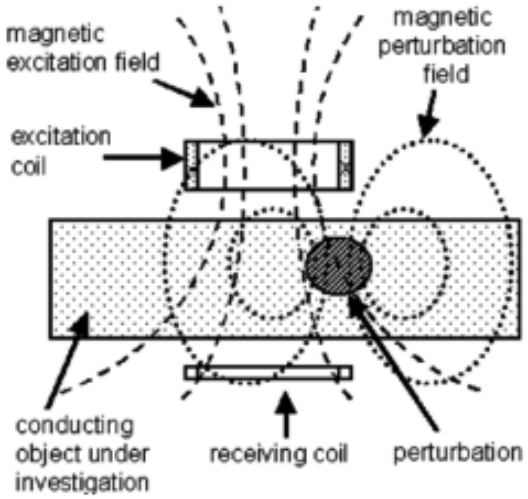


Figure 7 Principle of magnetic induction spectroscopy[20]

Based on Magnetic Induction Spectroscopy principle, jaundice measurement is started when the electromagnetic field generated at the transmitter, then propagates through the tissue of the baby's finger and reach to the receiver on the opposite side. Thus, the magnetic field will utilize phase shift. The jaundice level of the baby is determined by the phase shift value of receiver signal. Value of secondary field will increase when high frequency value of megahertz (MHz) is used. Megahertz is capable to use in this measurement due to the lower conductivity of biological tissue.

■4.0 CONCLUSION

Jaundice is a common problem that faced by every newborn infant. When the bilirubin level of new born babies exceeds the normal range, then the baby is considered as neonatal jaundice. Therefore, Magnetic Induction Spectroscopy (MIS) is one of the methods to determine total serum bilirubin of a newborn baby. Magnetic Induction Spectroscopy (MIS) is a non-invasive method and can avoid babies from getting a skin infection when a blood sample is drawn. This method should be explored and studied.

Acknowledgement

The authors would like to thank the Universiti Malaysia Perlis and Malaysian Ministry of Education for sponsoring this research under project FRGS 9003-00469.

References

[1] Houlihan, D. D., Armstrong, M. J., Newsome, P. N. 2011. Investigation of Jaundice. *Medicine (Baltimore).* 39(9): 518–522. doi:10.1016/j.mpmed.2011.06.008.
[2] Agarwal, R., Aggarwal, R., Deorari, A., Paul, V. K. Jaundice in the Newborn. *Div. Neonatol. Dep. Pediatr.* All India Instituate Med. Sci. Ansari Nagar, New Delhi. 1–16.
[3] Assessment Health. 2002.
[4] Robert, E. 1977. *Method for determinig Bilirubin Concentration from Skin Reflectance.*
[5] Friel, J. K., Friesen, R. W., B. 2003. *Bilirubin : Friend or Foe ?* 1–21.
[6] Martelanc, M., Žiberna, L. Passamonti S, Franko M. 2014. Direct Determination of Free Bilirubin in Serum at Sub-nanomolar Levels. *Anal. Chim. Acta.* 809: 174–182. doi:10.1016/j.aca.2013.11.041.
[7] Nag, N., Haider, S., Chaudhuri, R., Adhikary, S., Mazumder, S. 2009. Role of Bilirubin as Antioxidant in Neonatal Jaundice and Effect of Ethanolic Extract of Sweet Lime Peel on Experimentally Induced Jaundice in Rat. *Indian J. Biochem. Biophys.* 46(February): 73–78.
[8] Wang, X, Ã JRC, Chowdhury, N. R. 006. Bilirubin Metabolism : Applied Physiology. *Curr. Paediatr.* 270–74. doi:10.1016/j.cupe.2005.10.002.
[9] Fialová, L., Vejražka, M. 2013. Bile Pigments Porphyrins General Medicine.
[10] Fevery, J. 2008. Bilirubin in Clinical Practice : A Review. 592–605. doi:10.1111/j.1478-3231.2008.01716.x.
[11] Tenhunen, R., Marver, H. S., Schmid, R. 1968. The Enzymatic Conversion of Heme to Bilirubin by Microsomal Heme Oxygenase. *Proc. Natl. Acad. Sci. U. S. A.* 61: 748–755. doi:10.1073/pnas.61.2.748.
[12] Prince, R., Hospital, A.. R. P. A. 2004. Newborn Care Guidelines Incidence and Risk Factors: Consequences: Investigations: *Brain Inj.* 114: 297–316.
[13] British Columbia Reproductive Care Program. 2002. Jaundice in the Healthy Term Newborn. April:1–20.
[14] Neonatal Jaundice. 2012. *Queensl. Matern. Neonatal Clin. Guidel.* 1–35.
[15] Clinical Practice Guidelines. 2003. Management of Jaundice in Helathy Term Newborns. *Minist. Heal. Malaysia, Acad. Med.* 03(February).
[16] Your Newborn Baby' S Blood Test. *Newborn Screen. Free Heal. Checks Your Baby.* 1–8.
[17] Pethig, R. 1984. Dielectric Properties of Biological Materials: Biophysical and Medical Applications. *IEEE Trans. Electr. Insul.* EI-19(5): 453–474. doi:10.1109/TEI.1984.298769.
[18] Gabriel, C., Gabriel, C., Gabriel, S., Gabriel, S., Corthout, E., Corthout, E. 1996. The Dielectric Properties of Biological Tissues: I. Literature Survey. *Phys. Med. Biol.* 41: 2231–49. doi:10.1088/0031-9155/41/11/001.
[19] Martinsen, O. G., Grimnes, S., Schwan, H. P. 2002. Interface Phenomena and Dielectric Properties of Biological Tissue. *Encycl. Surf. Colloid Sci.* 7: 2643–2652. Available at: https://www.matnat.uio.no/fysikk/english/research/projects/bioimpedance/publications/papers/encyclop.pdf.
[20] Scharfetter, H., Casañas, R., Rosell, J. 2003. Biological Tissue Characterization by Magnetic Induction Spectroscopy (MIS): Requirements and Limitations. *IEEE Trans. Biomed. Eng.* 50(7): 870–880. doi:10.1109/TBME.2003.813533.
[21] Dávila, J. R., Gutierrez, J. C.P., Blanco, R. P. 2012. Use of Magnetic Induction Spectroscopy in the Characterization of the Impedance of the Material with Biological Characteristics. *Adv. Asp. Spectrosc.* 107–130.