

Bacterial Detector for Neonatal Sepsis

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ABSTRACT: Sepsis is the host response to microbial pathogens resulting in significant morbidity and mortality. An accurate and timely diagnosis of sepsis allows prompt and appropriate treatment. Current methods of bacterial detection rely upon laboratory-based techniques such as cell culture, microscopic analysis, and biochemical assays. These procedures are time-consuming and costly and require specialist equipment and trained users. In the present study, we developed a portable stand-alone biosensors for the detection of sepsis infection caused by *Staphylococcus aureus* and it can facilitate rapid detection and diagnosis at the point of care. The bacterial growth curve analysis was studied using colorimeter at 600nm. Further the N-(3-Oxodecanoyl)-L-homoserine lactone was incorporated into the sensor, which enables the detection of *Staphylococcus aureus* at various concentrations. Therefore, this biosensor could be useful in the detection of *Staphylococcus aureus* in sepsis infection.

KEYWORDS: staphylococcus aureus, acyl homoserine lactone, biosensor, Neonatal sepsis.

I. INTRODUCTION

According to world health organisation (WHO), the most critical time for child survival is the first 28 days of life, also known as the neonatal period [1]. In 2018, the infant mortality rate in India was at about 30 deaths per 1,000 live births. In this concern, we develop a medical application for detecting neonatal sepsis.

Sepsis is a potentially life threatening complication of an infection. Sepsis occurs when bacteria present in the body. *Staphylococcus aureus* is the most predominant bacteria in neonatal sepsis. This inflammation can trigger a cascade of changes that can damage multiple organ system, causing them to fail. If sepsis progresses to septic shock, blood pressure drops dramatically, which may lead to death. Neonatal sepsis is a kind of sepsis in newborn baby. It occurs when your baby gets a blood infection within the first weeks of life. In critically ill neonates with severe systemic infections, this is taken extremely long waiting period. For this reason, new methods and device for detecting neonatal sepsis for improve neonatal survival.

In this article we focus on the development of electronic device capable of early, safe and effective detection of bacteria in patient by non invasive approach.

In a previous work, blood culture are the gold standard in the diagnosis of neonatal sepsis. Another methods like lumbar puncture (spinal tap) will be done to look at the spinal fluid for bacteria. A chest x-ray will be done if a baby has a cough or problems breathing. Those methods are suffers from low sensitivity and a reporting delay of approximately 48-72 h and withdrawal of blood from infants are very difficult and painful process.

After this method, Daniel Benalcazar et.al determined that turbidity detection in blood serum in newborns. In this work introduces the engineering design of a device capable to detect serum turbidity. Although it is an electronic, portable and low cost device, it is an invasive method.

In this article we focus on the development of electronic device for detecting bacterial in neonatal sepsis. Initial tests to verify its functionality were conducted experimentally.

II. METHODOLOGY

Initial Consideration

Staphylococcus aureus-902 was purchased from MTCC, Chandigarh, India. Nutrient Agar medium, Nutrient broth, Gentamicin antibiotic solution were prepared.

Designing of Biosensor

Biosensors are analytical devices that employ sensitive biological materials to “recognise” certain molecules and provide information on their presence and amount as a signal convenient for recording and processing. Here biosensor is designed to detect the presence of bacteria by using chemical analyte coated with the sensor. It consists three basic components: recognition element which is a bioselective membrane involving various biological structures; physical transducer; electronic system for signal amplification and recording and for user friendly data representation [2,4-5]. Figure 1 represents a general scheme of biosensor. A recognition element is the basic component of any sensor. It is due to its recognition element that a sensor can selectively respond to one or several analytes among a large number of other substances. All types of biological structures such as enzymes, antibodies, receptors, nucleic acids, and even living cells are used as a recognition element in biosensors. Here we use chemical as a analyte that coated in biosensor.

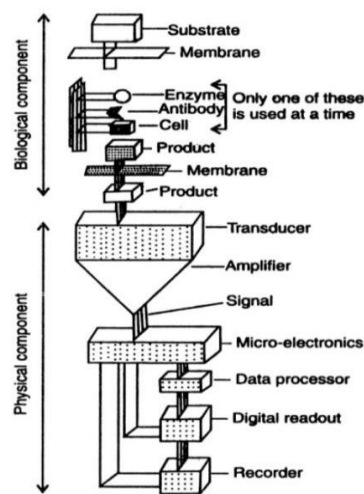


Fig.1. Block diagram of Biosensor

A transducer is used to convert biological signal into electrical signal. This signals then passed to electronic device.

Culture of Staphylococcus aureus

The microbial culture is a method to develop micro-organism under controlled laboratory conditions. We prepared pure culture for testing its biochemical nature and analyse its replication. This bacterial culture helps to analyse the bacterial growth in every weak.



Fig.2. Culture of staph. aureus

Growth Analysis

The growth analysis of bacteria will be done by using colorimeter. The concentration of color produced is proportional to the amount of pathogen that was present in the sample. Fig.3 represents the growth analysis of bacteria.

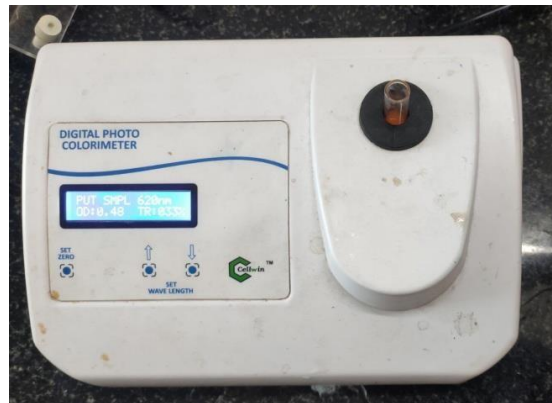


Fig.3. Growth Analysis of bacteria

The OD (Optical Density) value of the of the sample is measured in different concentration such as 5 ml culture, 2.5 ml broth with 2.5 ml culture, 3.5ml broth with 1.5 ml culture etc. Fig.4 shows the different concentration level of culture.

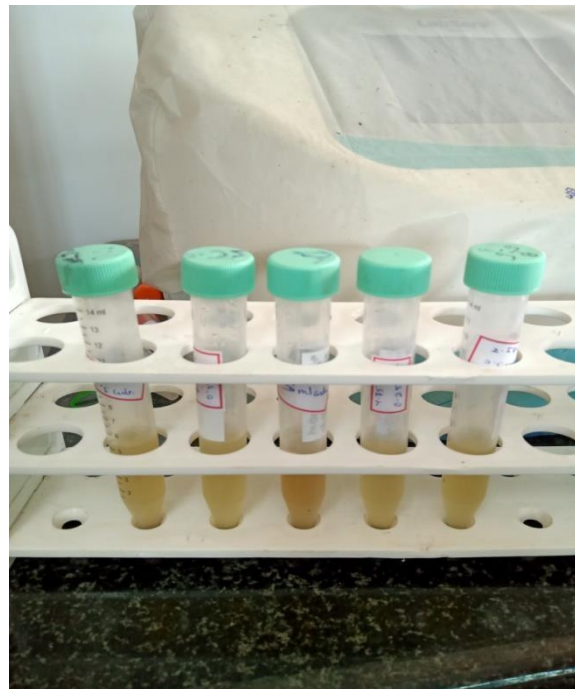


Fig.4. Bacteria culture at different concentration level.

The easiest way to gauge how far along a culture is in its growth curve is by measuring the optical density at 600nm. This measurement can be used to easily calculate the total number of cells per mL of culture in test tube. If OD value is 1, there is 8×10^8 cells/ml is presented. By using this, number of cells present in the sample will be measured. For example, the OD value of 5ml culture is 0.84. The number of cells present in 5ml culture is 6.72×10^8 ($0.84 \times 8 \times 10^8$).

Block diagram of Bacterial Detector

The block diagram of bacteria detector contain 4 units. Such as, sample, bio receptor, transducer and display. The sample is loaded into the device. It was sensed by using biosensor. Then this transfer to the bioreceptor unit. This unit receive signals and initiate a response. The analyte of the sample is measured.

Then this biosignal is transferred to transducer. Here biosignal is converted into electrical signal. This signal is further processed by electronic unit. The display shows the amount of microbial content present in human body. Fig.5 shows the block diagram representation of bacteria detector.

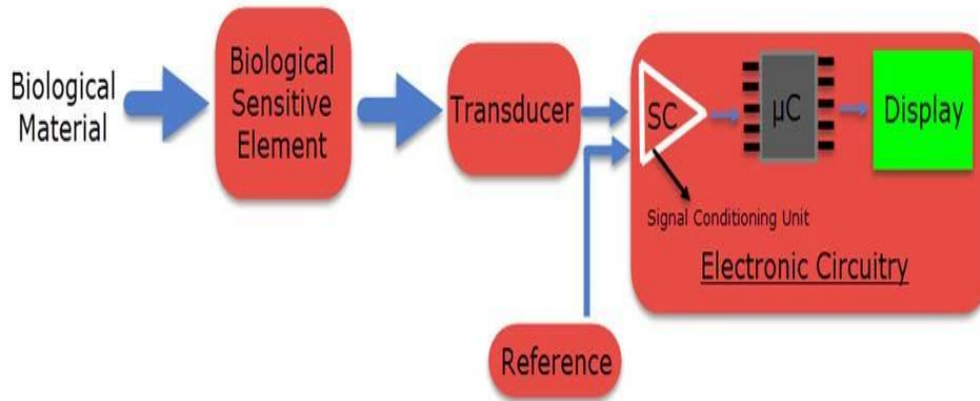


Fig-5:Block diagram of bacterial detector.

III. RESULTS

Automatic biosensor test ranges from 0.00-0.19%BAC (or 0.0-1.9 g/l). When your test result is equal to or greater than 0.05% BAC (or 0.5g/l), the “Danger” symbol will be displayed in the LCD display with beep audible alert. When your test result between 0.02% BAC (or 0.2g/l) and 0.05% BAC (or 0.5g/l), it only displays the “caution” symbol without beep alarm alert.

According to biosensor, *staphylococcus aureus* in clean air is 0.00mg/l. So we power the circuit and find the output voltage of N-(3-Oxodecanoyl)-L-homoserine lactone sensor in room air for normal is 0.00mg/l and in patient for *staphylococcus aureus* infection would be < 0.1 mg/l.

IV.CONCLUSION

Biosensor offer a rapid and cost -effective method of bacterial detection which can be performed at the point of care without the need for a specialist user. This “lab-on-a-chip” method of patient diagnosis and monitoring provides a more rapid diagnosis, which allows for faster and more effective therapeutic intervention, thereby preventing full-blown infection and mortality and also decreasing the spread of disease. It is a highly sensitive device with fast response time. By using this device,we can able to quantify the staphylococcus aureus microbial load or to identify the severity of infection using this biosensor in a short duration during sepsis infection. The main advantage of this device is a non-invasive approach without the need for sample processing. There is a particular focus on electrochemical biosensors, especially impedance – based systems,as these present key advantages in terms of ease of miniaturization, lack of reagents, and low cost.

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