Blood Leakage Detection System During Hemodialysis

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Abstract

The motivation behind this topic selection for study is to design and manufacture a supervision device for blood detection of blood leakage throughout hemodialysis. The given model include sensing element - conductivity sensor, microcontroller, alert components: LED and buzzer. The entire device is operated on 3v battery. Very small amount of blood can be detected in few milliseconds after blood leakage. Battery life of device is much long than currently available systems in the market. The objective of this system is to give alert when the sensor detects the blood leakage. When alert components or buzzer activate means there is blood leakage is caused, the healthcare or technician take immediate and appropriate action and prevent patient from any major problem during blood leakage in hemodialysis.

Key Words: Hemodialysis (HD), Blood leakage, Venous needle Dislodgement (VND), Conductivity sensor, Microcontroller.
1 INTRODUCTION

In the latest years, the number of patients with end stage renal diseases (ESRD) is growing in the developed and developing countries. There are different medicines or treatment for end stage renal diseases everywhere throughout the world, such as Hemodialysis, Peritoneal dialysis and kidney transplantation. [1]

Hemodialysis is most common and well known techniques for treating End Stage Renal Diseases (ESRD). Hemodialysis is a process that uses an artificial membrane or dialyzer to eject waste such as urea from blood and excess water from body. In Hemodialysis (HD), to clean blood, a special filter known as an artificial kidney or a dialyzer are used. To take blood from patients body or into artificial kidney, doctor needs an opening or entrance into vein. This is done with minor surgery. Normally, it is done to patients arm. As hemodialysis patients access or opening is one of the following:

- A fistula: in this surgery artery and vein are joined on patients arm
- A graft: in this surgery, to join an artery and vein to patient arm, a piece of soft tube are used.
- A catheter: in this the soft tube is placed in a large vein near patients neck.

Technician normally preferred fistula access, because it have two openings. Doctors and technicians placed needles into the access of each treatment. Blood goes to the machine in the dialyzer or artificial kidney through the needle. That needle are associated with delicate tubes that go to the dialysis machine and clean blood and came back to the patient’s body by means of delicate tubes. The dialyzer has two sections one for blood and another for dialysate liquid known as dialysate. A thin membrane isolates this two sections. Platelets, proteins and another critical things stays in blood since they are large in size to pass through the membrane. Little waste items, for example, potassium, creatinine, urea and extra water or liquids pass through the membrane. [6]

Hemodialysis is a lifesaving treatment. In this treatment some technical issues are may occur that technical issues may be related to patients characteristics like illness, access problem like as poor
needle placement, venous needle dislodgement (VND), extraction of needle, dialysis solution, equipment problem, operator problems, etc. [5]

From the above problems the complexity occurs in the venous needle dislodgement (VND) during HD. During HD, at a time about 500ml blood is outside of patients body and replace every minute. If blood leak occur in this system lots of blood is drained out from body in few minutes and patients loss his/her consciousness and death is possible in few minutes. The HD is a 4 to 6 hours process and there are no separate technician available for each patient who can monitor up to process completion. So automatic blood leakage device is required for monitoring the patient 24×7.

In HD, blood leakage caused due to venous needle dislodgement (VND). For this there are different methods are already present in market firstly, Hemodialert with the Hemosensor [6] in this method the sensing of blood is based on the change in voltage of the sensor. In this device two electrodes are connected to signal generating source through lead. Sensor output gives to signal processing unit which results in activate alarm. Second device for blood leak detection is Redsense [8] this is very sensitive device. It can shows results for 1ml of blood. Blood leak detection is based on electrical conductance changed in the line. The sensor is placed on the fistula access, when the blood leak occur sensor absorb blood and activate the alarm and visual indication. The third method or blood leakage detection device is capacitive sensor. [7] In this, blood leak detection is based on the change in capacitance. The change in wetness of blood is detected by capacitive sensor when blood leak occur. The fourth device present in market is photo interrupter sensor with absorbent material. [3] Photo interrupter is a transmission type photo sensor. It consist of light emitting and light sensing element facing each other in a single package. The absorbent material placed on the sensing area, when blood leakage occur blood absorb by the absorbent material very quickly and it brake the light penetration. This changes the voltage signal and activate the alarm. In this kitchen napkin is used as absorbent material.

The drawbacks of above methods is it operates in small distance, it required high operating power, bulky circuit arrangements, it cannot reuse for same or another patients because of safety therefore
its cost is high.
In this study to overcome all above drawbacks with the use of conductivity sensor. The conductivity sensor could be used. During hemodialysis when blood leakage occur due to venous needle displacement the sensor can sense leakage of blood and differentiate blood and sweat. This decrease the chance of confusion and enhances the human services nature of HD patients.

2 DEVELOPMENT OF BLOOD LEAKAGE DETECTOR

![Block diagram of Blood Leakage Detection System during Hemodialysis](image)

![CR2032 3volt Battery](image)

**A. System Overview**

The detection of blood leakage setup is apart in two parts. First part is hardware: blood leakage detection device and second is software which detect blood leakage during HD and activate the alarm through microcontroller. The purpose of this paper is the device is in small size, high sensitive, low amount of blood requires for leak detection, light weight, long life battery, easy operation and most important is low cost. The conductivity sensor is a sensing element of the detector. Microcontroller is the heart of the system.

**B. Block Diagram**

Blood leakage detection model block diagram is shown in Fig. 1. , this device operate on 3v battery. Conductivity sensor used as blood leakage detector and output signal sends to alert components that is buzzer through the microcontroller.

**C. Hardware Required**

i. Power Supply
Power supply is very important thing in any electronic circuit. For this device fixed 3volts power supply is required. CR2032 flat lithium battery is used. The life span of this battery is 5 years at room temperature because of this specification the CR2032 battery is selected as shown in fig. 2

ii. Atmel ATtiny 2313 Microcontroller (AVR Microcontroller):

The microcontroller is the heart of the blood leakage detection system which control all the operations. In this paper the Atmel ATtiny 2313 microcontroller is used which controls the output signal which come from conductivity sensor. Normally, the AVR center joins a rich instruction set with 32 universally useful working registers. All the 32 registers are specifically associated with the Arithmetic Logic Unit (ALU). Enabling two free registers to be access in one single instruction executed in one clock cycle. The gadget is made using Atmel’s high density non-volatile memory innovation. The On-chip ISP Flash enables the program memory to be reinvented In-System through a SPI serial interface, or by an ordinary non-volatile memory programmer. The Microcontroller used here is for a particular task to control the blood leakage locator framework. The Microcontroller can be improved and reduce the cost of production of the device. The pin diagram of AVR controller is shown in fig. 3. this pin diagram extremely valuable, it tells where the power and the ground to be associated, which pins connect to which practical equipment, and so on. This microcontroller operate on 3v battery.

iii. Conductivity Sensor:

Conductivity sensor has advantage that the liquid (Blood leakage) does not wet the electrical part that is metal leads of the sensor. Here, two conductivity leads or probes are used, which is set with known voltage signal or value. The liquid passing through a metal leads, it complete a circuit. The voltage difference which produce in the circuit is the output of the sensor. Sensor output is connected to the controller. When blood leak is occur, the leak blood completed the circuit and alarm is activated.
iv. Alert components:

Blood Leakage detector include both auditory and visual indication of alert signal. LED light and sound devices is used for alert. The device are as follows:

a) LED (Light Emitting Diode): A light-Emitting diode (LED) is a semiconductor light source. It creates light when an electric current experiences it. Driven are used as visual sign in numerous gadgets and widely used for other lighting purposes. Current LEDs have numerous advantages that are low energy consumption, enhanced power, small in size, quick exchanging. LEDs are all the more extreme for room lighting.

b) Buzzer: (HUDZ Buzzer 3V): A PCB mounting buzzer / sounder. Buzzer are used as auditory indication in many devices. It produces sound when an electric current goes through it. HUDZ Buzzer operating voltage and current is 3v and 30mA. Buzzer is an audio signal device.

v. Circuit Design:

The circuit configuration depends on the switch (on/off). In this circuit diagram, when blood leak occur sensor sense the leakage of blood and activate the alarm signal. When alarm
signal is activate, the technician or care taker come to patient and replace the conductivity sensor and reset the entire device or circuit. The circuit diagram shown in fig. 4.

D. Software Required

- AVR Studio 4:
  AVR Studio is an Integrated Development Environment (IDE) by ATMEL for developing applications based on 8-bit AVR microcontroller. Program of this device to sense blood leakage by sensor and send to alert components that is buzzer activation is done through this software. Writing and debugging of program is done in this software using assembly language program and IC burner kit as shown in fig.(5)

- Assembly Language Programming
- Extreme Burner

Fig. 5. AVR Studio 4 Software

Fig. 6. ATtiny 2313 IC Burner kit

Fig. 7. Flowchart of Blood Leak Monitoring Operation
3 BLOOD LEAK MONITOR OPERATION

Blood leakage detection is done using ATtiny 2313. The assembly language code is written according to the flowchart or process how to detect blood during hemodialysis treatment or process. The following fig. 7. Shows the flowchart of the blood leak detector throughout the 4 to 5 hours hemodialysis process.

4 BATTERY LIFE TEST SETUP AND RESULTS

In this study, the reason for the given detector device is to screen the blood leakage location throughout the dialysis treatment and battery life of the gadget is important. Battery life tests are under two states. One is the general checking state (without blood spillage), that is power down mode of controller. In the power down mode power consumption of microcontroller is 0.1 A at 1.8V and +25°C theory and in actual it is less than 0.1 A observed in the tests of battery life. And another state is the point at which the indicator continuously sends alarm or output signals (with blood spillage), that is idle mode or active mode of controller. In the active mode power consumption is 190 A at 1.8V.

The first general checking state (without blood spillage), that is power down mode of controller. In this condition, the blood leakage detector circuit is gone to sleep or power down mode of microcontroller. Before going to sleep mode the total circuit of detector is operate on +3volt supply. And 2.7v at power down mode or 1.8v
at active mode, is the battery low indication or discharge voltage level of battery. In power down mode, initially battery reading is 3.33v. In 24hours the voltage level drop from 3.33v to 3.22v that is 100mv. According to this the battery can continuous work without any interrupt or without any detection of blood leakage up to 6 days. After that the battery is discharge and circuit needs to change battery for better results or better performance as shown in fig. 8. A.

The second condition of battery life test is with blood leakage detect by detector. In this condition, when blood leakage occur due to VND the alarm get activated, and circuit shows the sudden change in the voltage level or voltage reading. This is the output signal of the sensor after blood leak detection. And in this case battery life span is 3 to 4 days. After that need to replace battery for better performance as shown in fig. 8. b. It could continuously send warning signal up to more than 24 hours under leaking condition.

In the battery life test setup the circuit of detector device consume very low power or voltage. Therefore battery life span is much longer than currently available device present in market. Detection of leakage of blood time in milliseconds. When leakage of blood is detected, it gives alert signal very quickly and activate the buzzer. The developed device is very sensitive and fast response.

5 CONCLUSION

In this study, the developed blood leakage monitoring device during hemodialysis is an independent system. This device is small in size, light weight, low cost and an easy installation on patients arm. The main purpose is to design and manufacture of this device is, to detect blood leakages during hemodialysis and activate the buzzer. When alert components or buzzer activate, the healthcare or technician take immediate and appropriate action and prevent patient from any major problem. LED and buzzer are used to detect battery low indication. Very small amount of blood is required for detection of blood leak and it detects in milliseconds. From the developed device hopes the quality of healthcare is enhancing during hemodialysis therapy.

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References


