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IV FLUID MONITOR AND CONTROLLER

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***Abstract*— In hospitals, ICU, CCU, NICU, OT, most of the departments have patients connected to an electrolyte bottle. An assist is responsible for monitoring of the bottle. But unfortunately, due to their busy schedule, the observer may forget to change the bottle at the correct time. If the bottle is not changed, there is a fatal risk of air bubbles entering the patient's bloodstream, which even causes immediate death. Our aim is to develop a device which detects the level of fluid in the electrolyte bottle and capable of sending notification to the nurse station and to control the flow of the electrolyte solution from the nurse station by using a common console. Such device will create assurity of non-harm conditions to patients and also helpful to monitoring of data and such data can be stored and will be useful in future. IR sensor is used to detect the level of drip bottle. This sensor is connected to microcontroller to monitor and alert the assist by the use of ESP8266 Wi-Fi module to the Blynk application. It also has features to control the rate of fluid flow from the common console.**

Keywords— **Electrolyte bottle, Backflow of blood, Thrombosis, Blynk, Emergency, IOT based applications.**

I. INTRODUCTION

Intravenous technology stems from studies on cholera treatment in 1831 by Dr Thomas Latta of Leith. Latta had observed that persons with cholera had lost huge amount of water content from their blood. Replenishment of this in combination with "oxygenating salts" was seen as key to patient recovery. The theory was then put into practice and was immediate success. IV rehydration was formerly a common technique for athletes. The person receives nutritional formulas containing salts, glucose, amino acids, lipids and added vitamins. The most commonly used crystalloid fluid is normal saline, a solution of sodium chloride at 0.9% concentration, which is close to the concentration in the blood (isotonic).

A. Types of access:

There are many ways to access fluids into body. Here the scope is restricted to peripheral venous catheter, as other techniques are out of scope of the proposed work. **Peripheral venous catheter** (**PVC**), peripheral venous line or peripheral venous access catheter is a catheter (small, flexible tube) placed into a peripheral vein for venous access to administer intravenous therapy such as medication fluids. The catheter is introduced into the vein by a needle, which is subsequently removed while the small plastic cannula remains in place.

B. Effects:

1) **Backflow of Blood*:*** The pressure inside your vein at least temporarily overcomes the pressure inside the IV, allowing blood to back flow into the line. Once the IV empties, that part of the tube hanging down over the side of the bed now has no force of gravity working on it. Therefore, as shown in figure 1 blood can come back out of your arm down into the tube.

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Fig.1. Backflow of blood in IV tubing
(*Courtesy:https%3A%2F%2Fslideplayer.com%2Fslide%2F257079%2F&psi*)

2) Embolism: A blood clot or other solid mass, as well as an air bubble, can be delivered into the circulation through an IV and end up blocking a vessel (figure 2); this is called embolism. Air bubbles of less than 30 micro liters are thought to dissolve into the circulation harmlessly. A larger amount of air, if delivered all at once, can cause life-threatening damage, or, if extremely large (3-8 milliliters per kilogram of body weight), can stop the heart. Its additional damage results from an inflammatory response that the air bubble initiates. These inflammatory changes can result in pulmonary edema, bronchospasm and increased airway resistance.

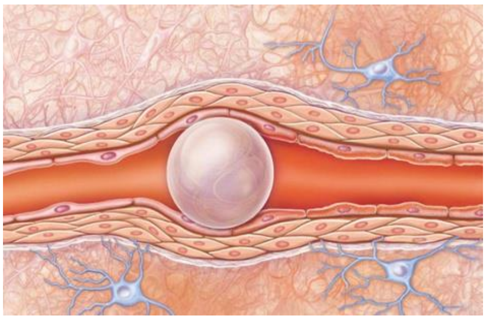

Fig.2. Air embolism in vein
(Courtesy:https://www.infusesafety.com/the-danger-of-air-embolism)

C. Estimates:

According to the **newsletter of the Australian and New Zealand College of Anaesthetists**, in **New South Wales** alone, between January 2012 and April 2015, there were **six reported deaths** due to central line-related air embolus [8]. According to the **Pennsylvania Patient Safety Advisory**, between June 2004 and December 2011,

Pennsylvania acute healthcare facilities reported **59 events** of confirmed or suspected air embolisms. Of that number, **34** were reported as "**serious events**" resulting in harm, including seven cases of permanent harm and **six deaths**. Of the 59 confirmed or suspected air embolism event reports, **24** were associated with **CVADs**. Various clinical studies show that air embolism due to catheter disconnection has a mortality rate between **29 and 43 percent** [8].

In addition to the risk of developing an air embolism, IV disconnection increases the risk of infection and may result in significant blood loss, especially in neonates and infants. Medication discontinuation is another adverse event associated with IV disconnection.

D. Case studies:

1. The dead body of a 14-year-old boy was brought for postmortem examination with allegations of death from negligence during treatment. He was treated for pain in the abdomen in a hospital. Following intravenous infusions, the boy died suddenly in respiratory distress. Gross findings indicated the death to be from venous air embolism [5] (Swapnil Sudhirkumar Agarwal et al, 2009).

2. A 56-year-old male weighing 60 kg was scheduled for live related allograft kidney transplantation. The surgery proceeded uneventfully with an adequate urine output. The trachea was extubated on the operating table and the patient was shifted to kidney transplant ICU for observation and further management. Subsequently one of the IV sets connected to the proximal lumen of CVP line had air in it and the IV fluid bag inside the pressure infuser bag was empty. The NS bag was reconnected and the pressure infuser bag was applied to it for the rapid infusion which resulted in air embolism as the saline infusion had finished unnoticed and the pressurized air entered through the central venous catheter leading to sudden fall in $EtCO_2$, HR, BP and SpO_2 .[4] (Deepanjali Pant et al, 2010)

3. A 68-year-old man who had been treated with intravenous antibiotics for pneumonia. The body was found with a peripheral venous catheter connected to a nasal cannula delivering oxygen (O_2) from the wall. During the external examination, massive subcutaneous emphysema was visible over the entire surface of the body. The CT scan revealed the presence of gas throughout the vascular system, and in the subcutaneous and muscular tissues. The autopsy confirmed the presence of lobar pneumonia and multiple gas bubbles in the vascular system [6] (Lionel Comment et al, 2017)

II. MATERIALS AND METHODS

When the patient is admitted in hospital, the IV line is commonly connected to the patient. The connected IV set will deliver fluids or nutrients or blood into the vein. The components of an IV set are shown in figure 3.

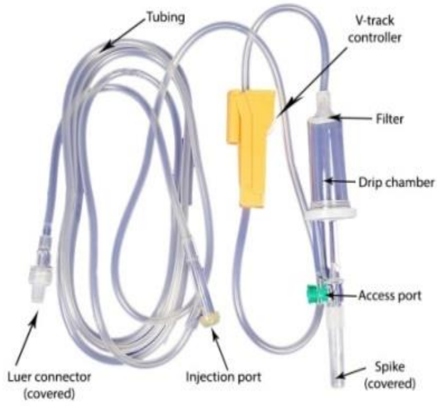

Fig.3. Complete IV set

(*Courtesy: https://www.dsmedical.co.uk/the-simple-iv-giving-set-i34*)

The spike is connected to the electrolyte bottle; from there the fluid is dripped into the drip chamber. The V track controller will control the speed of the fluid flow. The Luer connector is connected to the cannula at end. When the IV is attached it becomes gravity fed closed system. Once IV empties, that part of tube hanging has no force of gravity acting on it. Therefore, the blood will backflow through the tube.

A. Proposed model:

In order to detect the amount of fluid remaining in the electrolyte bottle, we used Load sensor and IR circuit. The load cell will be placed at the bottle holder and it need to be calibrated [13] (Snehashis Das et al, 2019). Since load cell has certain disadvantages like, it has to be calibrated first for few seconds and it will give erroneous results if the patient pulls the tube. Drip rate can be monitored by using IR photo detector [9] (C. Ram Kumar et al, 2019). So, we designed an **IR circuit** that has an IR LED and a photodiode to detect the light [1] [2] (Pooja, 2017) and (R. Shelishiyah et al, 2015). We concluded that if the sensor is placed at the position where the fluid is, the output of the IR photodiode is HIGH. We used 3 IR sensors at particular levels. These IR Sensor value is fed to the microcontroller (**Arduino UNO**). Arduino UNO is a microcontroller based on **ATmega328p.** It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an

ICSP header and a reset button. It contains everything needed to support the microcontroller. It can be simply connected to a computer with a USB cable or powered with an AC-to-DC adapter or battery to get started. Arduino programs are written in the Arduino Integrated Development Environment (IDE). **Arduino IDE** is a special software running on the system that allows the user to write sketches (synonym for program in Arduino language) for different Arduino boards. After the sketch is written in the Arduino IDE, it should be uploaded on the Arduino board for execution [14] (Leo Louis, 2016). From the microcontroller we used wireless transmission to the smart phone of caretaker. The wireless transmission was achieved using **ESP8266 (1) module** [3] (Tanvi G**,** 2017**),** which is a Wi-Fi module using TCP/IP protocol. The term Internet of Things (IoT) refers to controlling all electronic appliances over an android phone [3].

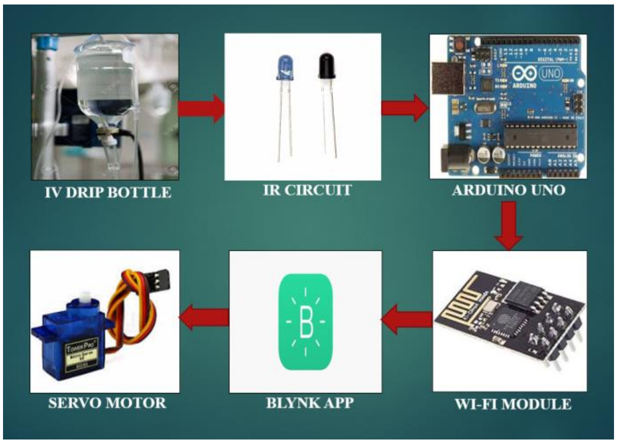

Fig.4. Block diagram

Based on the work of (Dr. K. Sampath Kumar et al, 2010) and (Anagha R et al, 2020) we made few changes to their work. We used blynk app and arduino to monitor the drip rate and can be easily notified to the nurses.

The **Blynk** software is currently used as the front-end for the caretakers to notify the level of electrolyte level. Blynk is a Platform with IOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets. The blynk can be easily interfaced by the arduino [7] (M. Todica, 2016). The developed page contains 2 value display boxes and a slider. The level of electrolyte present is shown in one display box and the alert is shown in the other display box. We add on a **servo motor** to control the flow of the electrolyte from the bottle. A servomotor is a linear actuator or rotary actuator that allows for precise control of linear or angular position, acceleration, and velocity. It consists of a motor coupled to a sensor for position feedback.

It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. The motor is attached by gears to the control wheel. As the motor rotates, potentiometer's resistance changes, so the control circuit can precisely regulate how much movement there is and in which direction. The slider in the Blynk app is used to control the angle of the servo. The application of servomotor in our project is to compress the IV tube whenever we require.

For circuit we designed IR sensors [1] [2] (Pooja, 2017) and (R.Shelishiyah et al, 2015), and establishment of IOT via Blynk app [15] (Dathar Abas Hasan et al, 2020). The motor can be controlled from the Blynk app by use of slider. The motor automatically compresses the tube if the fluid is in critical level.

III. EXPERIMENT AND RESULT

The results are interpreted in the Blynk app as shown in figure5. The final prototype is shown in fig 6. The IR circuit is placed in 3 positions such that at levels of 50, 10, 5 percentages respectively. The IR circuit will give a reading according to the level of the electrolyte remaining in the bottle.

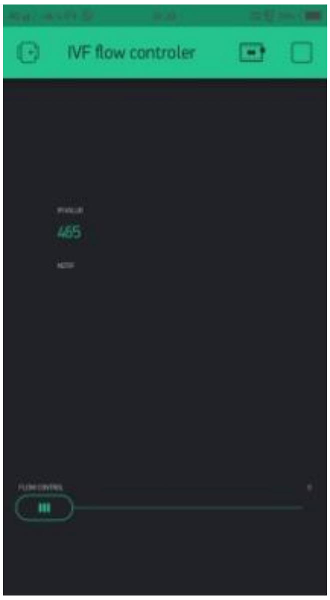

Fig 5a: Screenshot from the Blynk app

The IR value is shown in the Blynk app . If the value is above 330 or 350, then the position where the IR sensor is placed has fluid in it

IR Sensors	>50%	50% - 10%	10%	10% - 5%	5%
IR 1	480	159	161	170	165
IR 2	472	425	179	153	125
IR 3	468	454	465	397	168

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Table 1. Experimental results of IR values

Table 1 shows the different IR sensors placed at different positions (50%, 10%, 5%) respectively. If The value is below 330, the bottle is said to be empty or has no fluid in it.

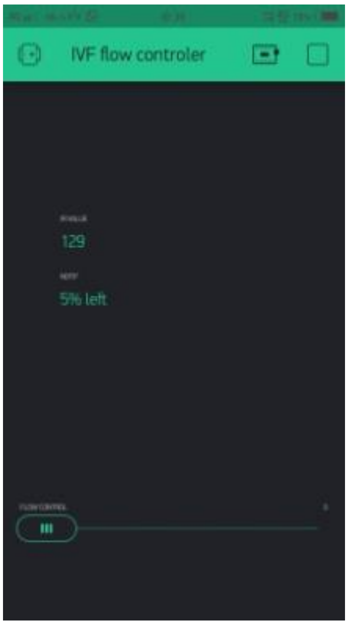

Fig.5b. Screenshot from the Blynk app

Figure 5b shows the Critical message that only 5% of fluid is left. These values are given to the microcontroller (ArduinoUNO). When the microcontroller gets a signal from the IR circuit that is placed at the 10% mark, the microcontroller alerts the nurse station by a warning message. If the microcontroller encounters a signal from the IR circuit at 5% mark, then the nurse station will get critical alert with the bed number of the patient. Then an automated servo powered motor will compress the tube leaving no flow of the electrolyte.

The nurses can control the flow of the electrolyte to the particular person according to their condition from the nurse station itself. The Blynk app will display the IR value of respective IR circuit; it also gives a notification at 10% and 5%. The slider option will allow nurses to control the flow of the electrolyte by controlling the movement of servo motor

IV. CONCLUSION

This project work will be useful for government and general hospitals. The advances we looking forward is to keep a centralized station for nurses to reduce their workload and to indicate critical situation for the patient. The model is shown in figure 6.

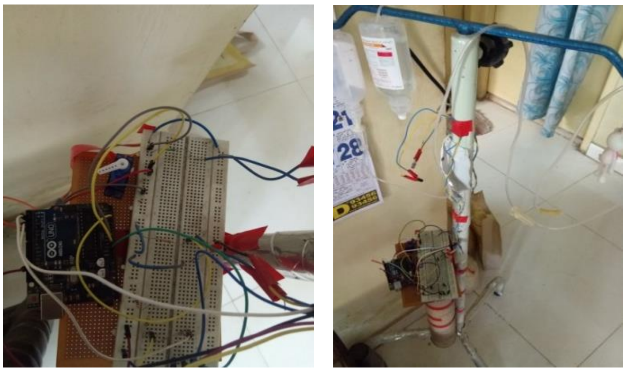

Fig.6. Final prototype of IVF Flow controller and monitor

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