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Implementation of an Off-Hospital Rural and Urban Public Access Defibrillator

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Abstract: The occurrence of out-of-hospital cardiac arrest (OHCA) is a critical life-threatening event that often warrants initial defibrillation with a semi-automated external defibrillator (SAED). In INDIA, about 4280 deaths in 1Lakh are due to SCA. The optimization of allocating a limited number of SAEDs in various types of communities is challenging. Hence this paper presents the implementation of an off-hospital rural and urban public access defibrillators. This defibrillator is a semi-automated defibrillator, a medical device which analyse the patient's electrocardiogram in order to establish whether he/she is suffering from ventricular fibrillation and if necessary, delivers an electric shock, or defibrillation, to help the heart re-establish an effective rhythm.

Keywords: Sudden Cardiac arrest; Ventricular defibrillation; Electrocardiogram; Semi automated external defibrillator; Cardiopulmonary resuscitation

I. INTRODUCTION

Cardiovascular diseases accounts for 24.8% of total deaths in the country. Primarily the age population is affected by this disorder.

Most unexpected cardiovascular passing are brought about by strange heart rhythms called arrhythmias. The most widely recognized perilous arrhythmia is ventricular fibrillation, which is a flighty, complicated terminating of driving forces from the ventricles (the heart's lower chambers). At the point when this happens, the heart can't siphon blood and demise will happen in practically no time, whenever left untreated. The only solution to ventricular fibrillation is to defibrillate the patient's heart by providing a short-termed, high voltage shock.

An AED is a device that delivers therapeutic dose of shocks to assist with re-establishment of constant heart rhythms of a cardiovascular distress victim. With simple pictorial commands, AEDs are design to be simple to use for the layperson.

An AED can be used on an adult, child, or infant by following the prompts and commands given by the equipment.

The proposed design of an Off-Hospital Rural & Urban Public Access Defibrillator consists of 3 stages of operation-

- Power Supply stage
- Oscillator stage
- Voltage Booster stage

which are explained in detail further in the later stages of the paper.

II. LITERATURE REVIEW

In [1], the paper basically speaks about the importance of Automated External Defibrillators as an immediate clinical assistance for SCA patients. Defibrillation is the most reliable method of treating a SCA, namely a medical dose of electric energy. The need to perform defibrillation within a few minutes of SCA has led to the development of AEDs: their timely use after SCA can improve outcome.

For this reason, AEDs were designed to be used with little or no medical knowledge and technical training that would allow the global reach of these devices to reduce victims of SCA. [1] also states that "AEDs should be present in public places with the highest probability to have SCA events, such as public transportation areas (train stations or airports), shopping malls, schools and colleges, working areas etc."

In paper [2], untrained laypersons can use semi-automated AEDs sufficiently quickly and with minimal instructions. The finding that realistic performance metrics (i.e. time to first shock, precision of the positioning of the electrode pad and safety) were substantially improved after limited theoretical guidance, but without technical instruction in the use of the instrument. One of the most extraordinary findings is that after giving marginal instructions, all tested laypeople were able to deliver a shock in less than 1 min, irrespective of whether the automatic or semiautomatic mode was being used. Finally, the paper concludes that laypeople need only a minimum of prior knowledge to use an AED quickly and safely, and that further implementation of AEDs for use by minimally trained persons without any medical training is possible.

Paper [3] states, "*Use of automated external defibrillators (AEDs) by first arriving emergency medical technicians (EMTs) is advocated to improve the outcome for out-of-hospital ventricular fibrillation (VF)*".

In paper [4], in order to make the actual energy of defibrillation approximate to target defibrillation energy in automated external defibrillator, aa energy compensation method is used. This is undoubtedly a real blessing for medical instruments, in pursuit of safety and stability. The research on energy compensation of defibrillators has made a considerable achievement, but energy compensation still has big space for improvement, and further research needs to be continued.

In paper [5], the paper presents a novel compositive algorithm by merging a slope variability analyzer with a band-pass digital filter to accurately distinguish shockable rhythms from non-shockable rhythms for automatic external defibrillators.

III. METHODOLOGY

A defibrillator is a mechanism that sends the heart through a high-energy electric shock. A high-energy shock is called defibrillation. The aim of this shock is to restore a heart to its usual state of operation if it goes into cardiac arrest.

When a patient shows symptoms of a cardiac arrest, a defibrillator may be used to bring their heart back to its usual rhythm. A cardiac arrest occurs when the heart abruptly stops pumping blood throughout the body, usually due to an electrical signaling malfunction in the heart. If the heart stops pumping blood through the body, the brain is needy for oxygen and can even cause a person to lose consciousness and stop breathing.

The most sudden cardiac deaths occur from irregular heart rhythms called arrhythmias. Ventricular fibrillation is the most severe life-threatening arrhythmia, which is an uncontrolled, uncoordinated firing of ventricular impulses (the lower chambers of the heart). When this takes place, the heart is unable to pump blood, and if left untreated, death will result within minutes.

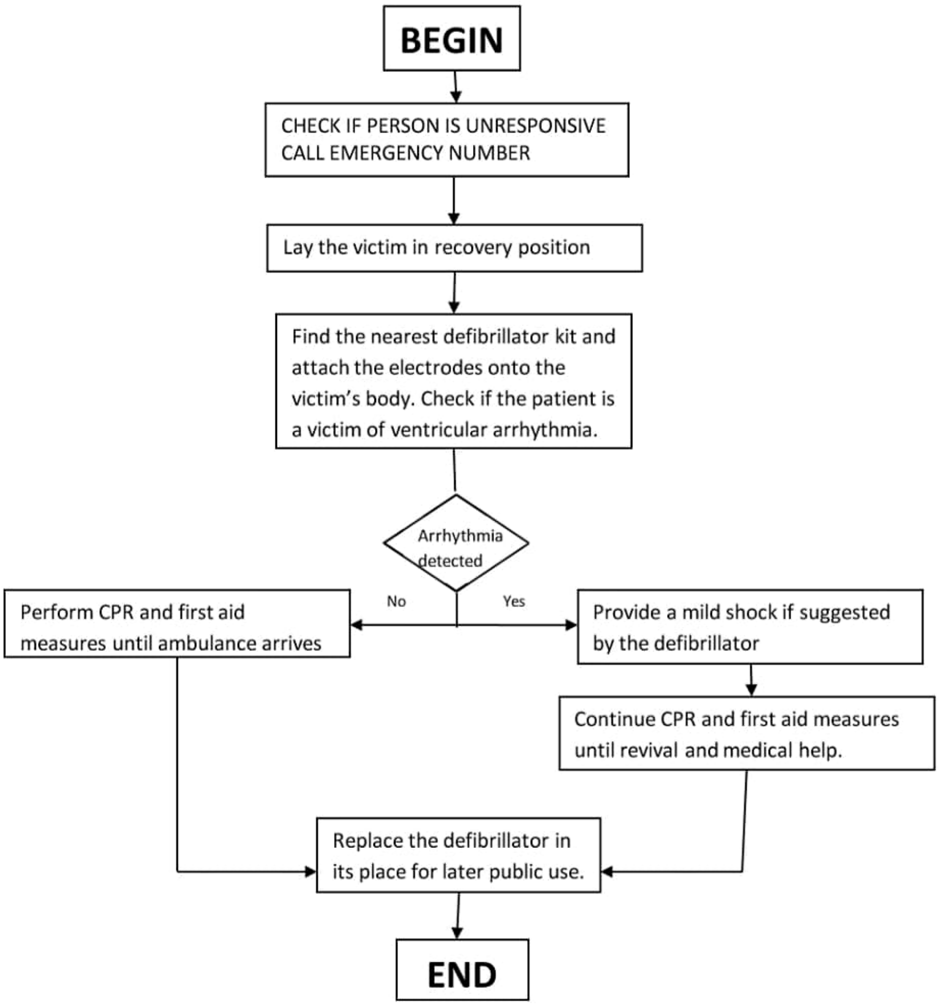

Fig 1. Flowchart of Mechanism of Defibrillation

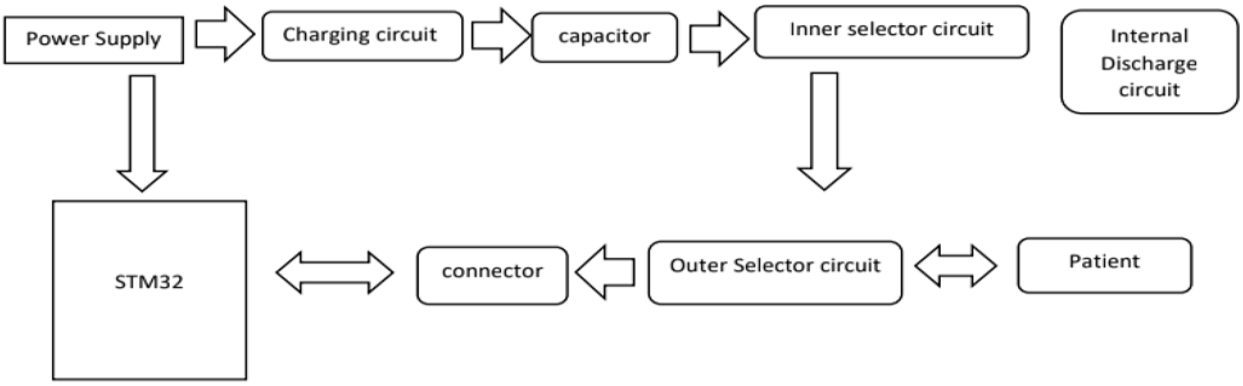

Fig 2. Block Diagram of Semi-automated defibrillator

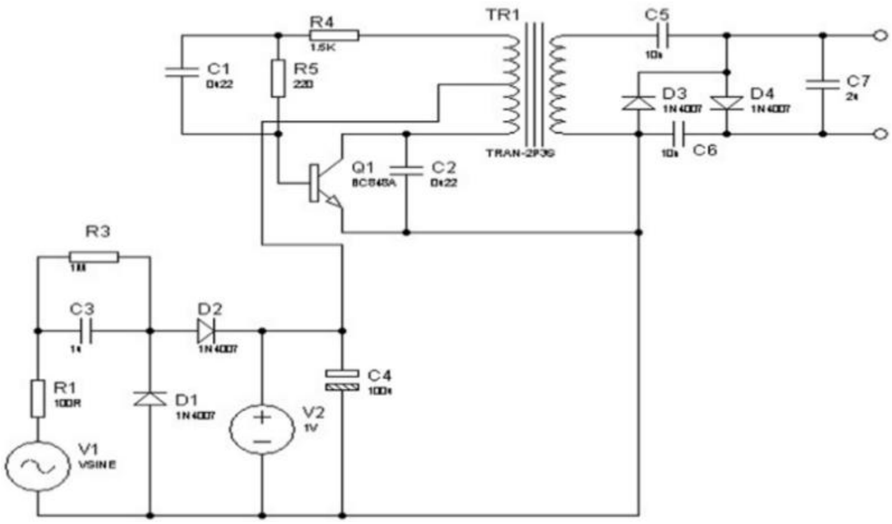

Fig 3. Defibrillation Circuit

A cardiac arrest is considered a serious medical emergency and care needs to be taken immediately, or it may be dangerous. When a person experiences cardiac arrest, they will be unconscious, inoperable and therefore they do not breathe, or they do not breathe normally. In such cases emergency treatment includes Cardiopulmonary Resuscitation (CPR) and defibrillation. Pressing on the chest can cause a sore chest, broken ribs or a collapsed lung. CPR may not be able to restart your heart. Hence, we go for defibrillators.

An AED can be used on adult, child and infants by following a few simple instructions provided on the AED kit. The electrode paddles are placed in particular positions on the victim's body and the AED is allowed to analyze the victim's body. Once the analysis is done, and the victim is diagnosed with ventricular fibrillation, a high-energy, electric shock will be recommended for defibrillation.

The flowchart in Fig. 1 describes the mechanism of Defibrillation.

A. Working of Defibrillator circuit

Making reference to the figure above we find that, essentially, the circuit consists of three stages viz. The power supply stage, the oscillator stage, and the voltage booster stage.

a) Power supply stage

This section consists of three major components: The Transformer, the Bridge Rectifier and the Filter Capacitor. Electromagnetic induction is used by the transformer in order to step down the AC mains. But the voltage under consideration is still of a low voltage AC and hence needs filtration and rectification. Rectification is achieved by the bridge rectifier (including 4 rectifier diodes) and this rectified voltage is further filtered to create a clean DC at the output by the previous electrolytic filter condenser.

To operate with 3V DC supply, the winding inside the coil is determined, meaning that the circuit is made compatible with a 3V battery pack made by placing a few cells into series.

The transistor and the centre tapped transformer immediately start oscillating at the specified high frequency when power is applied to the circuit. The battery current travels in a push pull way through the TR1 winding. Switching operation produces a proportional high voltage generated by the secondary TR1 winding, this voltage generated is somewhere around 200V.

b) Oscillator stage

The oscillator stage mainly consists of an oscillator which helps in conversion of DC input applied as shown in the circuit (Fig.3) to a square wave or an oscillating current fed to the secondary winding of a power transformer. In the present circuit Blocking oscillator circuit concept is used, A blocking oscillator is one of the simplest form of oscillators which is able to produce self-sustaining oscillations through the use of just a few passive and a single active component. The name "blocking" is applied due to fact that the switching of the main device in the form of a BJT is blocked (cut-of) more often than it's allowed to conduct during the course of the oscillations, and hence the name blocking oscillator. R1 along with the pre-set and the C1 determine the frequency of oscillation. R1 ensures that the transistor never comes within an unsafe zone while adjusting the pre-set.

c) Voltage booster stage

According to [21], "*To further enhance and lift this voltage to a level which may become suitable for generating a spark, a charge pump circuit involving a Crockcroft-Walten ladder network is used at the output of TR1.This network pulls the 200V from the transformer to about 600V.This high voltage is rectified and applied across a bridge rectifier where it is completely rectified and it is stepped up by the 2µF/1KV capacitor*."

As long as the output terminals are kept at a specified distance around the 2µF capacitor, the high-voltage energy stored within the condenser cannot be discharged and remains in a standby state.

When the terminals are bought at a comparatively closer distance (about a few mms), the potential energy through the 2µF capacitor is theoretically capable of breaching the air barrier to arc through the terminal gap in the form of a flying spark.

Once this happens, the arcing stops momentarily, until the capacitor fully charges to execute another spark, and the cycle continues to repeat as long as the gap is kept within the saturable distance of the high voltage.

The circuit also contains a small charging circuit which can be connected to the mains to charge the rechargeable 3V battery when the battery stops producing enough arcing voltage when giving shock.

IV. CONCLUSIONS

The defibrillator is currently recommended as the best resuscitation technique which can be widely used by any layperson to deliver a shock manually. It has been shown to decrease mortality rates and neurological deficits of victims of out-of-hospital cardiac arrests.

The proposed design of defibrillator is a powerful therapeutic tool. The advancements are making the defibrillators easier to use, cost effective and user convenient for public usage.

AED services are adopted as a proactive and culturally appropriate step, providing a significant advantage to communities and public health.

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