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A Device to Reduce Vasovagal Syncope in Blood Donors

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***Abstract*—Vasovagal Syncope (VVS), or the transient loss of consciousness is the most widely recognized reason for syncope. (VVS), is a typical dysfunction of the autonomic nervous system. There are various factors which can influence the syncope. The major classification of the syncope are reflex(neurally mediated) syncope, syncope due to orthostatic hypertension, Cardiac syncope(cardiovascular). The vasovagal syncope is the part of reflex (neurally mediated)syncope, there are various cause of vasovagal reactions but in blood donation it is mediated due to the pooling of blood at calf muscles. Such near syncope incidence while donating the blood or after donation hampers the future motivation for blood donation of the donors. In this paper, we developed an electronic massager for calf muscles that can reduce the risk of VVS. It has a programmable circuit which can control the vacuum pump so that it can inflate and deflate the cuffs synergistically. The massager can relax the blood donor thereby reducing apprehension prior to blood donation and thus diverting from the trigger of Phlebotomy and improve peripheral blood circulation thereby improving venous return to the heart. This is expected to reduce the risk of VVS.**

***Index Terms*—VVS(Vasovagal Syncope), Phlebotomy, WB(Whole Blood), BCAs(Blood collection agencies),VVRs(Vasovagal reactions).**

I. Introduction

Syncope is defined as a transient and self-terminating loss of consciousness with rapid onset, combined with sponta- neous, quick and complete recovery. Syncope is classified by global cerebral hypoperfusion. It is classified into three groups: reflex syncope, syncope due to orthostatic hypotension, cardiac syncope and its detailed classification is shown in fig.1. VVS is a type of reflex syncope mediated by emotional or orthostatic stress and is entertained by the produce of autonomic activation, (such as sweating, pallor and nausea). Neuropsychologically mediated is the inducement of vasovagal reactions that are the most routine cause of transient loss of consciousness during surgery [1]. Donating blood is safe and healthy, a few donors experience adverse reactions either during or after the procedure. The most common adverse event is a VVS. VVSs are triggered by various physical (e.g. standing up after losing about 500mL of blood) and psychological stimuli (e.g. pain, stress, fear [2]. During a VVS, the donor experiences a drop in arterial blood pressure and cerebral perfusion, which reduces blood flow to the brain [3]. Vasovagal symptoms can last several hours causing prolonged discomfort. If the donor experiences syncope, can result in fall-related injuries such as fractures and head injuries [4].A single centre study of vasovagal syncope reaction in blood donors in India was conducted by Joseph Philip and his team, and they reported 1085 VVRs among 88201 donations which

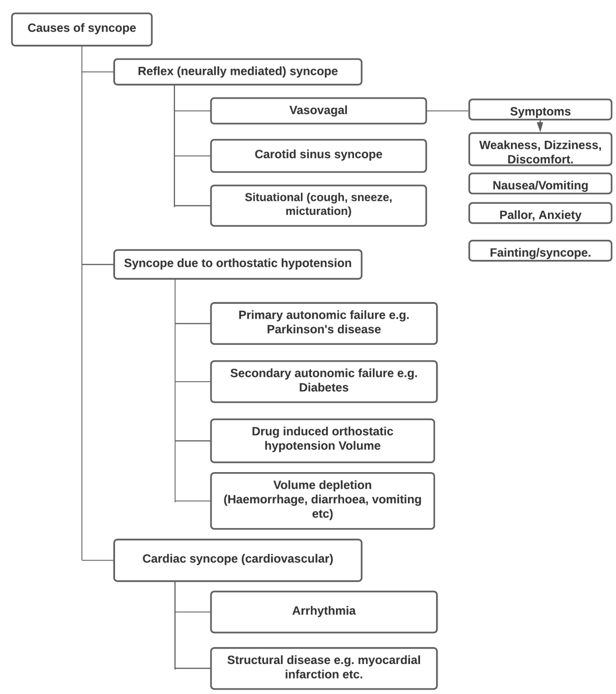

Fig. 1. Classification of Syncope.

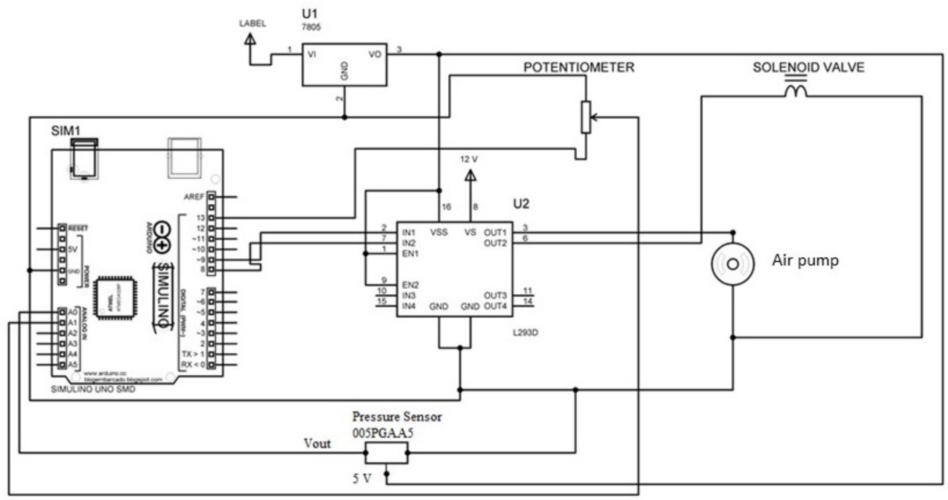

Fig. 2. Circuit diagram of the device

amounts to an occurrence a rate of 1.23%. in their study they have considered various influencing parameters like age, sex, donation status, weight, total blood volume and volume of blood collected [5]. Recently, another study was published in nature claimed 0.004% phlebotomy VVS and VVRs at a frequency rate of 2-5%, study suggested that use of more than 5 blood collection tubes and a waiting time of more than 15 min were associated with a higher risk of VVS[6]. Avoiding VVS is very important to BCAs as it affects the rate of the completed collections, perceptions of the safety of blood donation and rates of donor return. There are various physical maneuvers reported(e. g., leg crossing, muscle tensing and squatting)that are effective in combating orthostatic intolerance but all require counselling and physical training guidance and many physical activities are limited by body weight, height and gender[7][8]. As per American Red cross survey found that just 22% of the young donors were willing to do muscle tension as prescribed (alternate leg raising every 10 s during the entire phlebotomy).There are lots of other methods to communicate with donors through an enhanced donor recruitment brochure, use of audio, video. However all these methods are cumbersome and time consuming[9]. Epidemiologically, VVR is more likely to occur in women and younger donors [10]. Here in this paper, we are proposing a low cost, low power, compact and portable electronic massager unit which might serve as a convenient addition to the blood donation chairs and may reduce the rates of VVS on donors. This massager is envisaged to reduce apprehension prior to blood donation and thus diverting from the trigger of phlebotomy and improve peripheral blood circulation (minimizing peripheral pooling of blood) thereby improving the venous return to the heart. This paper is a complete description of the prototype development and performance from design and usability perspective. Clinical validation of this shall be reported in a later publication.

II. Implementation of System design

A. Hardware

Fig. 2 shows the circuit diagram of this massager. The circuit boards are powered by a 12 V DC supply that can draw power directly from home AC supply. This voltage is then downconverted to 5 V through a LM-7805 IC which powers an arduino board. This arduino board has an ATMEGA328 programmable microcontroller. We use the I/O and the ADC pins of this to control the inductive loads and the read the pressure values in the cuff respectively. The two inductive loads are the air-pump and the solenoid valve. These are controlled by the microcontroller through an H-bridge IC - L293D. This IC has its motor power supply pin (pin no. 8) connected to the 12 V DC supply on board which ensures that both motor and the solenoid are powered at rated voltages. The air-pump, solenoid valve and the pressure sensor are all connected in one single continuous air-way path which terminates in two large pressure cuffs. Appropriate T-connectors were used to divide the air-way path between the pressure cuffs. A pressure set-point knob is provided on board that can set the upper limit of the pressure that is built-up inside the cuffs. This knob is mounted on a potentiometer which again is read through the ADC of the microcontroller chip.

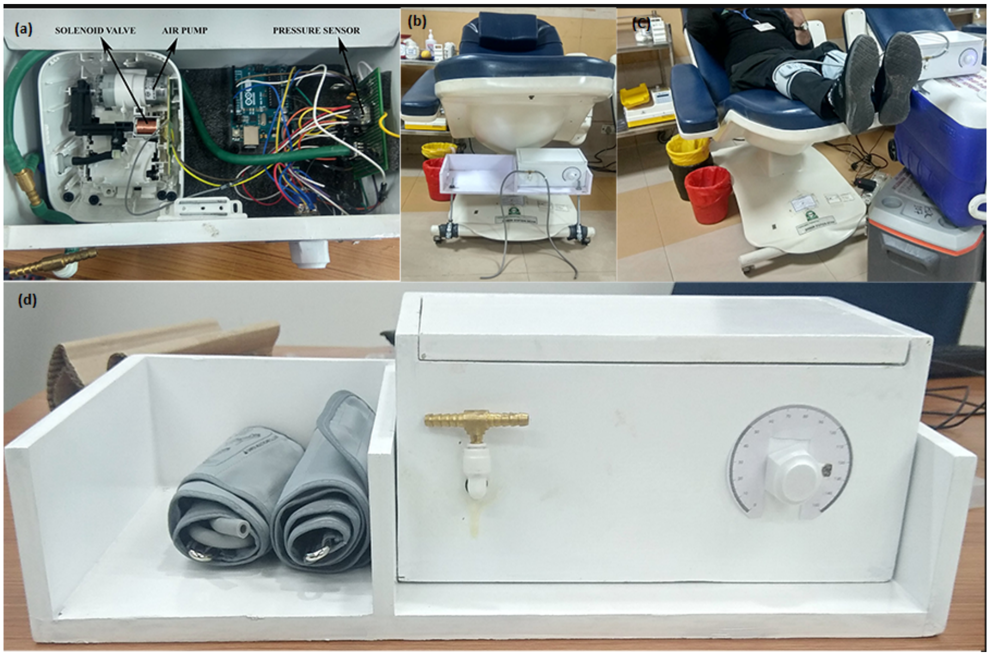

Fig. 3. (a) Electronic components used in device,(b) Placement of device in Blood donor chair, (c) Device demonstration, (d) Final look of the device.

B. Software

Fig. 4 shows the algorithm of the device. When we switch on the device, the program first checks the pressure setpoint set by user through the potentiometer knob. If setpoint is higher than the current pressure in the cuff then the valve is closed and air pump is started. The pumping is continued till the pressure in the cuffs reach setpoint. As soon as that happens, the air pump is shut down and valve is opened to release the pressure slowly. This process is repeated throughout the operation of the device. User may reset the set-point at any time through the potentiometer knob.

III. Operation of the Device

This device should ideally be mounted on the blood donation chair itself. After the patient lies down on the reclining chair, the two cuffs are applied to the calf muscles on both legs (Fig. 5). To operate this device first a low pressure set-point is set by the operator and then the device is powered on. The cuffs start to inflate and deflate as per the pressure ceiling set by the knob. The setpoint is increased slows until can feel a relaxing massaging effect on the calf muscle. If the pressure set-point is set too high, the patient may feel uncomfortable and in this case the setpoint should be brought down by appropriate control signal through the knob. After this the blood donation process is started. Once the donation is complete, the device is turned off and the cuffs are gently removed before the patients deboards the donation chair.The final look of the device is shown in fig.3.

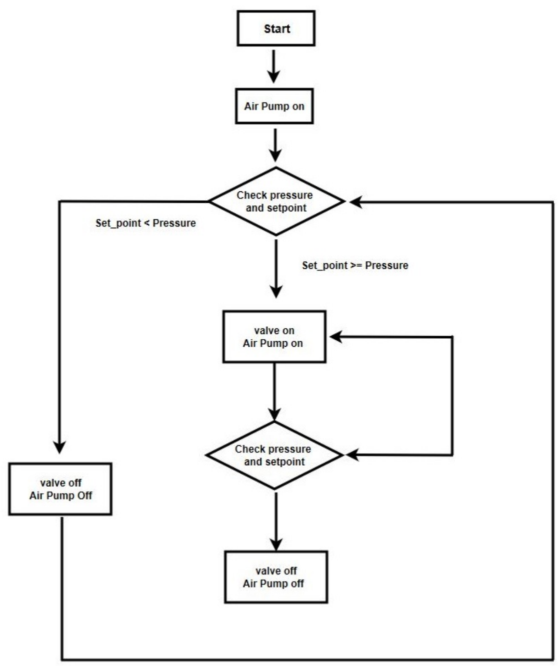

Fig. 4. Flowchart of the algorithm

Fig. 5. Picture depicts the exact placing site of cuffs at calf muscles
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IV. Results

Fig 6. shows the results of the pressure recordings from the pressure sensor during a normal operation. In this example, pressure set-point is slowly being increased and the series of six pressure cycles can be visualised for six increasing set-points. As envisaged, the pressure in the cuffs rises and falls between minimum pressure point and the maximum set-point providing a massaging effect to the calf muscles of the patient. In the future, we plan to place this device in the transfusion medicine department of one of the major hospitals of India and carry out a clinical validation of the utility of this device in reducing incidences of VVS.

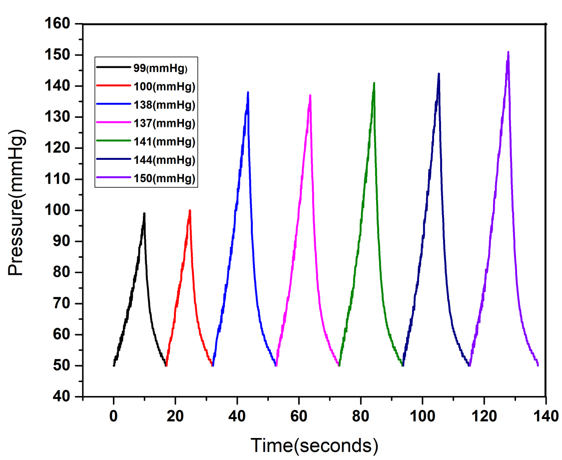

Fig. 6. Graph showing the inflation and deflation rate in accordance with time at particular pressure point set by the potentiometer..

V. Conclusion

This paper presents a simple, safe and portable device for reducing incidences of VVS in blood donors.It is non-invasive and non-pharmacological. It works just by providing a massage to the calf muscles of the donor thereby pumping back the pooled blood to the heart which can improves the heart rate and systolic blood pressure of the donor and also prevents the mental diversion that may avoid triggering of a vasovagal syncope. This proposed device may help in the reduction of drop-out rate of blood donors due to vasovagal reactions.

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