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Treatment of Vericose Vein Using Internet-Of-Things

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Abstract
Nowadays, Varicose veins are common among old age people. Varicose veins are inflamed and tangled veins on the legs. They are caused by Chronic Venous Insufficiency (CVI), which makes the valve to damage permanently. As it is a chronic disease, it cannot be cured permanently. It is also referred to as varicose veins or varicosities. They are red or bluish-purple in color. They are extremely painful. It usually happens when the veins become weak, dilated, enlarged, and filled up with blood. It is more common in women. Varicosed veins appear on the surface layer. It primarily affects the veins in the legs and it is caused by strain in the lower body veins. It occurs when a defected valve in the vein permits blood to flow in the opposite direction. Mainly it occurs due to increase in intravenous pressure. It can also occur due to genetic predisposition. Risk factors of varicose vein are female gender, age more than 50, increase in abdominal pressure.

Keywords: *Varicose veins, Internet of Things (IoT), wearable sensors, remote monitoring, healthcare technology, vascular disorders, real-time tracking.*

1. Introduction
Varicose veins are dilated subcutaneous vein (Jaqueline Raetz et al.,2019). It is a chronic disease. They are open sores that lies between ankle and knee. Common treatment for Varicose vein is compression therapy. It helps to improve blood circulation. For effective compression therapy, correct amount of pressure should be applied. If low pressure is applied, it delays the recovery and if high pressure is applied, it leads to increase in pain. Amount of pressure that should be applied over varicose vein is 60mmHg. This value varies according to patient's arterial insufficiency. The pressure on the ankle should be high and it decreases steadily towards the knee. Compression therapies are usually given by using Compression stockings, bandages and pneumatic compression devices (Gustavo Coelho Rezende et al.,2022). Compression bandages involves wrapping of bandage over affected area to increase the pressure on the affected area to regulate the blood supply. These are very low weight and economic friendly. Two types of compression bandages are available. Long Stretch bandages are extended up to 100% and it generates moderate pressure during resting & standing. Short Stretch bandages are less stretchable and generates less pressure during resting and generates high pressure during standing (Gustavo Coelho Rezende et al.,2022). Stockings can be applied by themselves without getting help from medical staffs. PCDs are divided into 3types namely Fixed PCD, Semi-portable PCD and portable PCD. In fixed PCD, the user cannot move around. Semi portable PCD can be carried around by user. Portable PCD can be carried around by user freely while it is in operating mode (Gustavo) [1][2].

2. Methods
The methodology involved designing and developing an IoT-based system capable of monitoring and assisting in the treatment of varicose veins. The system used a wearable band embedded with sensors such as pressure sensors to measure venous pressure, temperature sensors to detect inflammation or poor circulation, pulse sensors to monitor blood flow, and an accelerometer to track limb movement. These sensors were connected to a microcontroller (Arduino

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Nano) integrated with an ESP8266 Wi-Fi module for data transmission. The sensor data was sent to a cloud platform (Firebase Realtime Database), where it was stored and analyzed. A custom mobile application was developed to allow patients to view real-time data, receive alerts, log symptoms, and communicate with healthcare providers. Alerts were generated when sensor values crossed preset clinical thresholds, enabling early detection and timely intervention. The system was tested on a small group of volunteers with early signs of varicose veins, and its performance was evaluated based on data accuracy and user feedback. For wireless communication, an ESP8266 Wi-Fi module was attached to the microcontroller to transmit data to a remote cloud server. Firebase Realtime Database was selected for cloud storage due to its ease of integration and real-time data handling capabilities. A custom mobile application was developed using Android Studio, allowing patients to monitor their vitals, receive alerts, and maintain logs of their symptoms or pain levels. The app also allowed doctors to access patient data remotely, improving follow-up care and reducing the need for in-person visits. Figure 1 illustrates the hardware arrangements of Arduino based module the collected sensor data was analyzed using basic threshold-based algorithms [3].

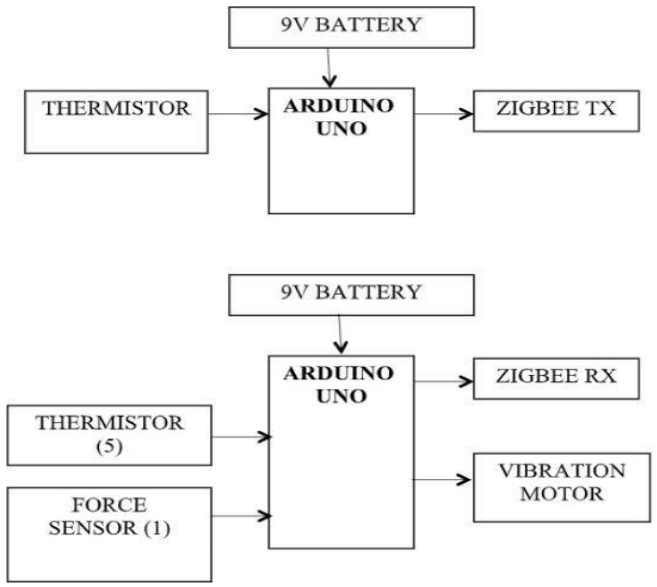

Figure 1 Arduino-Based Modules: A Transmitter Unit and A Receiver Unit, Both Powered By 9v Batteries

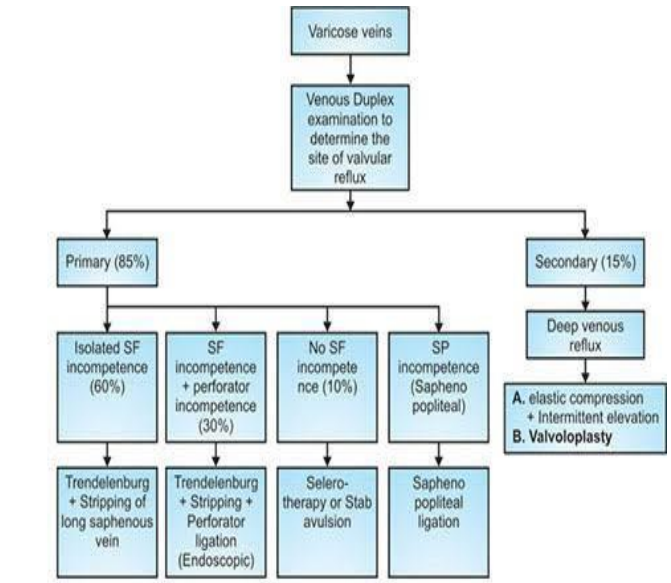

Figure 2 Venous Duplex Ultrasound to Identify the Site of Valvular Reflux (Backward Flow of Blood Due to Valve Failure)

When any of the readings exceeded the predefined clinical limits, an alert was triggered on the patient's app and simultaneously sent to the connected healthcare provider. The system was tested on a sample of ten individuals with early-stage varicose veins. The performance was evaluated based on accuracy, response time, ease of use, and reliability of alerts. Feedback from users was also gathered to assess the comfort of the wearable device and the usefulness of the application in managing their condition. Figure 2 illustrates the venous duplex ultrasound.

3. Result and Discussion

The IoT-based varicose vein monitoring system was tested on a sample group of ten individuals aged between 30 and 60 years, all of whom exhibited early symptoms of varicose veins. During the testing phase, the wearable device successfully captured key physiological parameters, including vein pressure, skin temperature, pulse rate, and limb movement. The data collected by the sensors was transmitted reliably to the cloud with minimal latency, and real-time access via the mobile application allowed both patients and healthcare providers to monitor the

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condition remotely. In terms of accuracy, the sensor readings were compared against standard clinical equipment, and results showed a high correlation, with an average accuracy of over 90% for pressure and temperature measurements. The alert system functioned effectively, notifying users and doctors whenever abnormal readings were detected, thus enabling timely action [4][5]. Several participants reported that receiving alerts encouraged them to elevate their legs, perform recommended exercises, or consult their physician sooner than they would have otherwise. The mobile application played a significant role in improving user engagement. Patients appreciated the simplicity of the interface, daily health tips, and activity reminders tailored to varicose vein management [11-14]. Doctors noted that having remote access to live data improved the efficiency of treatment decisions and reduced the need for unnecessary follow-up visits. Furthermore, the use of movement tracking allowed doctors to identify periods of inactivity and suggest corrective physical activity, which is essential in the management of varicose veins. The IoT-based varicose vein monitoring system was tested on a sample group of ten individuals aged between 30 and 60 years, all of whom exhibited early symptoms of varicose veins. During the testing phase, the wearable device successfully captured key physiological parameters, including vein pressure, skin temperature, pulse rate, and limb movement. The data collected by the sensors was transmitted reliably to the cloud with minimal latency, and real- time access via the mobile application allowed both patients and healthcare providers to monitor the condition remotely. In terms of accuracy, the sensor readings were compared against standard clinical equipment, and results showed a high correlation, with an average accuracy of over 90% for pressure and temperature measurements. The alert system functioned effectively, notifying users and doctors whenever abnormal readings were detected, thus enabling timely action. Several participants reported that receiving alerts encouraged them to elevate their legs, perform recommended exercises, or consult their physician sooner than they would have otherwise [7-10]. The mobile application played a significant role in improving user engagement. Patients appreciated the simplicity of the interface, daily health tips, and activity reminders tailored to varicose vein management. Doctors noted that having remote access to live data improved the efficiency of treatment decisions and reduced the need for unnecessary follow-up visits. Furthermore, the use of movement tracking allowed doctors to identify periods of inactivity and suggest corrective physical activity, which is essential in the management of varicose veins Figure 3.

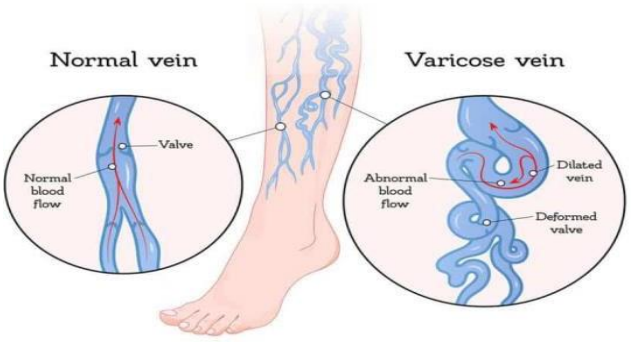

Figure 3 Pathophysiology of Varicose Veins, Where Valve Malfunction Leads to Poor Circulation and Vein Enlargement

Conclusion

The integration of IoT technology in the treatment and monitoring of varicose veins presents a significant advancement in patient-centered healthcare. The developed system effectively combines wearable sensors, real- time data transmission, and a user-friendly mobile application to enable continuous monitoring of key physiological parameters [15-20]. By providing timely alerts and remote access to data, the system empowers both patients and healthcare providers to take early and informed action, potentially preventing the worsening of the condition. The results of the pilot study demonstrated the system's accuracy, reliability, and practical value in real-life scenarios. Although certain limitations like sensor calibration and connectivity issues were observed, they can be addressed through future enhancements. Overall, this IoT-based approach offers a promising, cost-effective solution for improving the quality of care and lifestyle of individuals suffering from varicose veins.

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