Early Detection Of Pressure Sores Using Non Invasive Infra-Red

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Abstract: One of the serious problems for bedridden patients is that they require a device which can detect pressure ulcers at an early stage. In order to test the efficacy of the device, a tissue phantom material was needed to reduce testing costs and optimize specific device parameters. In order to accomplish this task different potential phantom material were investigated and tested to determine which specific material would be able to replicate the electrical response of human skin across a wide range of frequencies. Potatoes were able to replicate a similar bio-impedance response to that of humans and were modified to simulate a pressure ulcer. The Galvanic Skin Response (GSR) Sensor system can measure complex impedance of different human tissues in the range of 10Hz to 1MHz based on direct digital synthesis technique. Old measuring systems are based on Phase sensitive detection where as the new (GSR) Sensor system shows its integrity in theoretical analysis and simplicity in practical implementation Pressure ulcers are major health problem where hospitalized patients are more affected and approximately 3 million people are suffering with this problem across the world. According to the statistics in 1993, Pressure sores were observed in hospital stage of around 280,000 and this number has increased to 455000 in 11 years. Pressure ulcers are injury to skin and underlying tissues caused by constant pressure.

Index Terms: Pressure ulcers, Arduino, GSR sensor, Conductance, Hospitalized, Direct digital synthesis technique, Human skin.

1. INTRODUCTION

WE can observe pressure ulcers in mostly hospital bedridden patients and elders at home, this type of long stays result in sepsis or death [1] is a primary etiology of pressure ulcers is tissue ischemia and today it is considered that in most cases such damage can be prevented [2]. First step in pressure ulcers prevention is the identification of those patients who are at high risk [1, 3], identification at right time will help the health care to start preventive strategies [4]. Literature survey reveals two methodologies in the identification of pressure ulcers which are risk assessment scales and clinical judgment. However, both of them are not good enough to evaluate the risk of pressure ulcers, which contribute to prevalence of pressure ulcers and high incidence Unfortunately, Risk Assessment Scale scores which were established from early 1960s [5], are based on subjective grading. Major limitations of subjective grading based on RASs are sensitivity and specificity [3]. RASs mark only the tendency towards the pressure sores development instead of predicting the risk precisely [6]. Nevertheless, this method lacks quantitative assessments and mostly limited to expert experiences.

One of the challenging factors regarding the pressure ulcer detection is that they will not progress sequentially from one stage to other stage that is from symptom to tissue damage. Often pressure ulcers seen on the surface of the skin begin deeply inside the tissues very close to the bone, and finally burst out on to the surface of the skin. So as to effectively identify the risk of pressure ulcers objectively over traditional methodologies, a key factor in the early detection of ulcers is to identify the underlying pathological changes of tissues before any surface symptoms occur. A novel approach to monitor changes in the electrical properties of tissue, bio-impedance spectroscopy is proved in recent years' studies that it is a trustworthy diagnostic tool to determine the physiological status of living tissues [9].The present paper proposes an innovative solution of galvanic skin response (GSR) for pressure ulcers risk assessment based on improved two polar methods as shown in fig. 1.

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2 LITERATURE SURVEY

Pressure ulcers are commonly called as Bed sores or Decubitus ulcers occur as a result of damage to the skin and subcutaneous tissues locally as a result of prolonged pressure over bony areas of the body. In addition to pressure, shear forces and friction forces on weakened skin can also a use pressure ulcer to form on a patient's skin. Pressure ulcers form a serious problem in the health care industry and negatively affect both patients and caregivers on a global scale. In recent years, it has been found that up to 15% of acute patients develop pressure ulcers during their stay at hospitals. In addition, the incidence rate for pressure ulcer development has increased by approximately 60% in the same time period. Along with the deep physiological pain experienced by bed-bound patients, who are most prone to this type of injury, there are steep financial costs associated with pressure ulcers. It is said that that a typical healthcare provider incurs an average cost of $48,000 for a pressure ulcer occurrence which amounts to a national outlay of almost $11 Billion [1]. Every year approximately 2.5 million patients obtain hospital acquired pressure ulcers which cause over 60,000 deaths per year. As pressure ulcers obtained in hospital cases are more severe they can cost the hospital upwards of $150,000 per patient in addition to other legal settlement costs for malpractice cases [1]. A number of different research papers were studied for pressure ulcer detection. A report of literature survey is presented here. Yuxiang Yang 2005: Introduced BIS (Bio Impedance Spectrometer) method to find out the elusive changes in the electrical properties of in-vivo tissues where it is risk assessment and reliable to detect the PU (Pressure Ulcers). Marie Fagan 2015: his goal was to use Barden scale to

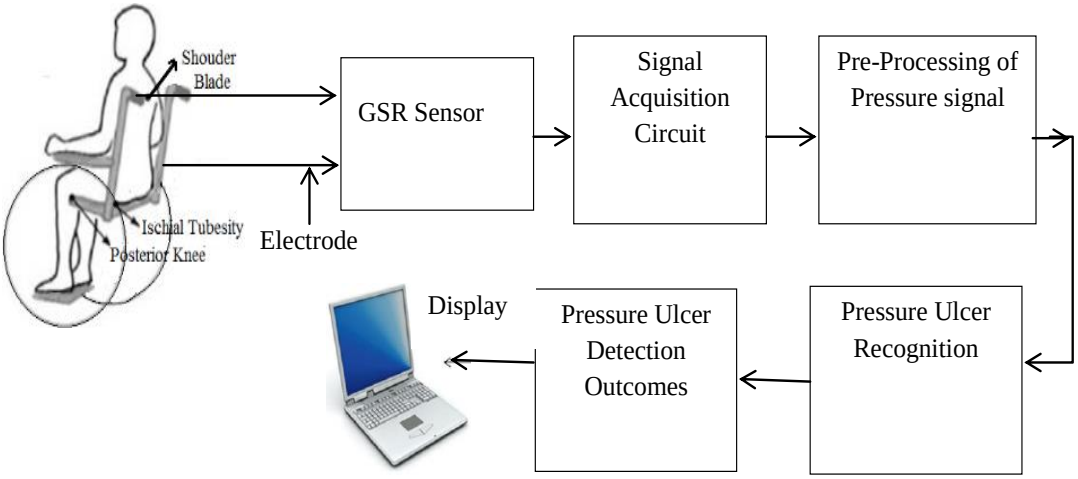

Fig. 1: *Architecture of the proposed system*

predict pressure ulcers score risk which is added to the initial critical rooms. Maryann L. Lancaster 2015: The main purpose of this type of practice is used to device the HAPU prevention program at Trihealthand assess an emerging preventive strategy which utilizes a high-risk assessment tool and intervene with a soft silicone foam-bordered to reduce HAPU development. SEM scanner was found to be one of the reliable devices to detect early stage pressure ulcers the SEM Scanner detects early, pressure-induced tissue damage and is a portable, hand-held, wound assessment device. The accuracy of SEM scanner found to be twice that of old and conventional techniques also less time consumption in detection. It indicates tissue damage one week to ten days well in advance before the visible symptoms or pressure ulcer formation. Philip Chung 2013: Modern screening and prevention techniques to assess risk for bedridden sores formation and repositioning the patients for every two hours is labour-intensive and can be subjective, a Bluetooth-enabled fabric-based pressure sensor array is a simple tool to objectively assess and continuously monitor pressure ulcer risk. Sarah Yang 2015: To design a rare type of bandage which can detect pressure ulcers as and when they start forming, before the damage erupts on to the surface of the skin. The device was helpful in detect in erratic degrees of tissue damage reliably across several animals.

3 METHODOLOGY OF SYSTEM DESIGN

Galvanic skin response can be measured by an instrument which measures most critical impedance in different frequency ranges and is easily available instrument in the market with wide variety of designs. Though there are many varieties of GSRs available, Galvanic Skin resistance based instruments can be categorised into two main classes like: a) General GSRs which can be used for any general purpose or medical purpose and they lack medical safety regulations. b) Medical GSRs which are only used for medical applications like measuring body fat percentages, this type of GSRs are not suitable for localised tissue measurements but confined to total human body impedance measurements. Additionally, the frequency spectrum is restricted to a narrow level that may not suit for the intended circuit requirements. It is evident from the reasons mentioned above creation of portable galvanic skin response (GSR) suitable for measurement of tissue impedance non-invasively in wide frequency range of 10Hz to 1MHz in the regions where pressure ulcer is prone. GSR system circuit diagram is shown in fig.2. We use a simple low pass filter to avoid high frequency components which is included in the circuit. Extremely pure silver electrodes (having silver with purity of 99.999%) are used to measure the GSR. Safe and imperceptible small voltage is applied across the skin using these small plate electrodes. When the sweat gland fills further increase in skin conductance is not possible which is known as saturation effect. Skin's capacity to conduct the current traveling through it increases as the excess sweat increases the sweat gland activity. The level of sympathetic nervous system arousal changes due to changes in skin conductance. Analog digital converser saturates to 2.35V. The microcontroller has a built-in ADC of 16 bit with a resolution of:

$$2.35/65535=3.5v \quad (1)$$

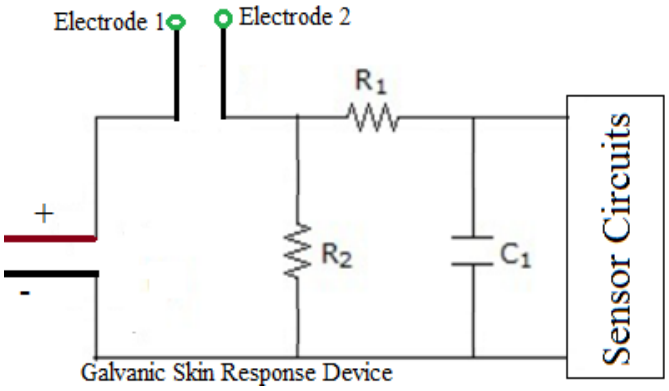

Fig. 2*: The circuit diagram of the GSR*

The galvanic skin response lies in the 10kΩ and 1MΩ range (Sharma and Kapoor, Villarejo et al., 2012) which is evident from the existing studies on skin conductance got by applying different voltages. An operational amplifier need not be included as ADC with 3.5V resolution and 1.36mV of minimum tension. This concept helped in achieving the third objective, that is, energy efficiency. The property of the skin is to act as resistance for the passage of electric current. GSR is calculated by placing two electrodes on the fingers. One resistance was used to find out the GSR value as shown in fig.3 which is in series to form a voltage divider with the skin resistance. It is found out that the output tension Vo is

proportional to the inverse of the skin resistance value. The resistance of a person decreases if he/she is in the stress as his/her hands will sweat. It is concluded that the output voltage will be high for the person under stress.

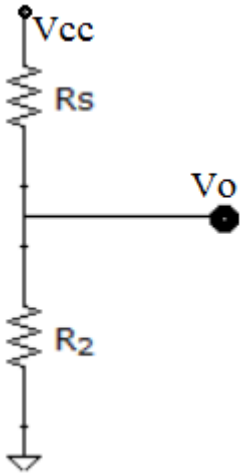

Fig.3: *The voltage divider circuit of the GSR.*

Rs-represents the skin resistance $Vo = \frac{R_2}{R_s + R_2} V_{cc}$

4 RESULT DISCUSSIONS

In the below obtained graph 20 subjects were studied in which some of them are normal persons and remaining are the patients who are admitted in the hospital for longer duration and performed the analysis on different age group, from the studies it is observed that more affected areas were elbow and foot where the conductivity is less. Different values of various persons are shown in the below fig. 4.

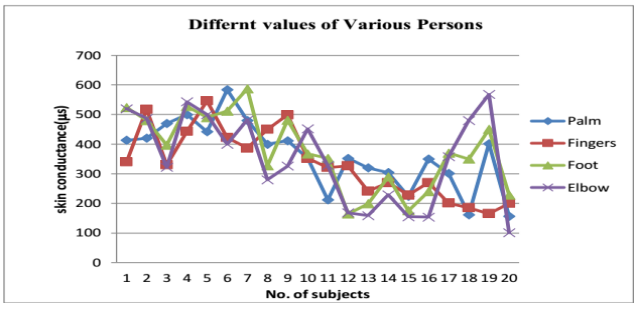

Fig. 4: *Different values of various persons*

By taking the values of different age group people there is a change in conductance due to the skin tone and aging. If the values are below the normal value i. e. 100-200, it is said that the pressure ulcer is formed and the physician can take care of the patient. The general data of subjects studied data given below the table consists of No. of subjects count and No. of males and female count and also the minimum, maximum and mean values of age and obtained GSR values are show in the below table. By analyzing the observed collected database, it has been found that some of the patients are prone to pressure ulcers. General data of subjects studied is given in the below table1, it is tested for the normal persons who are healthy and found that they are not prone to PU.

GENERAL DATA OF SUBJECTS STUDIED			
No. of Subjects	20		
No. of Female	11		
No. of Male	9		
	Min	Max	Mean
Age(years)	22	60	44
GSR	101	682	391

Table 1: Data of subjects studied

After collecting 2 person data from two different hospitals, those who were hospitalized and found that they are prone to PU. From the above fig. 5, and the acquired database it has been found that the patient is mostly prone to foot ulcer and the below graph the patient is prone to elbow ulcer is shown in fig. 6 and 7.

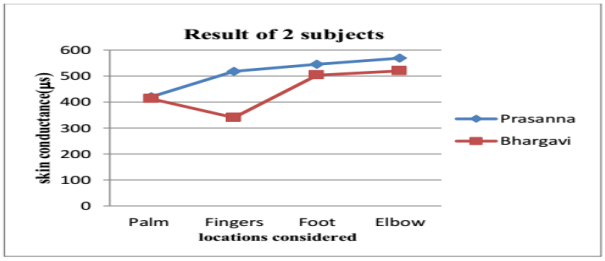

Fig. 5: *Results of 2 subjects*

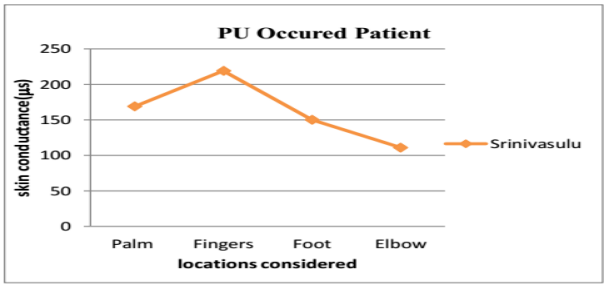

Fig. 6: *PU occurred patient. (Srinivasulu)*

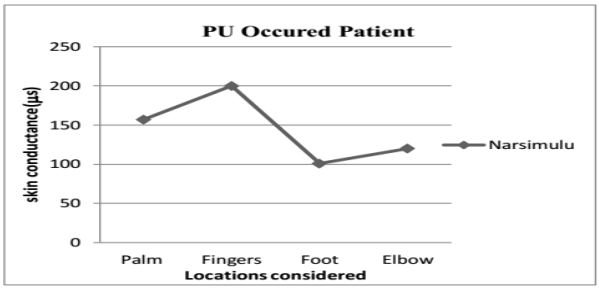

Fig. 7: *PU occurred patient (Narsimulu)*

5 CONCLUSION AND FUTURE SCOPE

A portable device is developed which can be used easily by any technician to find the pressure ulcer prone zones. By comparing with all the other methods this skin conductance method is useful for predicting the values and accuracy is good. So the other methods also have the pros and cons but this method of finding the pressure ulcers is different from all the other methods. This study quantitatively assesses the galvanic skin response of the skin by using the GSR sensor. The GSR sensor is placed on two fingers to find the conductance of that area. In real clinical practice it is much more difficult to detect the pressure ulcers in the early stage. The physicians come to conclusion that when they see the wound physically on the developed area. There are more chances of getting the pressure ulcers in the hospitalized people. After the analysis has taken on the different subjects on different age groups the conclusion is drawn that the study may help the physicians to detect the pressure ulcers before they arise there is a chance of preventing the pressure ulcers. In conclusion this study has demonstrated that based on the analysis done and results obtained the skin conductivity can be measured to detect the pressure ulcers in the early stage.

Future Scope

Restrictions were made from entering into ICU's for analyzing our project for these long term bedridden patients. This increased the enthusiasm in finding the conductance values or pressure ulcer prone zones for these ICU patients. The drawback of the project is continuous monitoring of the Pressure ulcer proneregions. So it can be proposed for future work using a fabric sensor which can continuously monitor the pressure levels at different regions for a bedridden person with clear color coding indication for different pressure regions. Fabric sensor can be incorporated in the mattresses and can monitor the patient frequently, so it would get results of continuous monitoring.

REFERENCES

[1] E.A. Ayello "Predicting Pressure ulcer risk," Medsurg Nurs, vol 12, p p .130-1, 2003. 4

[2] Bjorklund, L., Basch, A., Borregard, B., Brown, B., Denno, J., Montgomery, E., Pedicini, K. &Saporito, J. (2012). The Pressure is on An Innovative Approach to Address Pressure Ulcers in the ED Setting. The Journal of Emergency Nursing 38 (2).

[3] Pham, B., Teague, L., Mahoney, J., Goodman, L., Paulden, M., Poss, J., Li, J., Ieraci, L., Carcone, S., &Krahn, M. (2011). "Early Prevention of Pressure Ulcers Among Elderly Patients Admitted" Through Emergency Departments: A Cost effectiveness Analysis. Annals of Emergency Medicine 58 (5).

[4] J Ramsay, "Pressure ulcer risk factors in the operating room," Advances in WoundCare11 (May/June1998)5-6.\

[5] M Lindgren et al, "Immobility—A major risk factor for development of pressure ulcers among adult hospitalized patients: A prospective study," Scandinavian Journal of Caring Sciences18 (March 2004)57-64.

[6] B A Ferrell et al, "Cost-effectiveness of low air-loss-beds for treatment of pressure ulcers," The Journals of Gerontology, Series A, 50 (May 1995) Ml41-M146.

[7] Allman, R., Gosenell, D., Bergstron, N. and Cuddigan, J. (1993). Individual risk factors. In Panel for the Prediction of Pressure Ulcers in Adults. Pressure Ulcers in Adults: Prediction and Prevention. Guideline Technical Report, Number 3. AHCPR

[8] Publication No. 92-0013.Rookville, MD: Agency for Health Care Policy and Research, Public Health Service, U.S. Department of Health and Human Services. (703) 487-4650

[9] Brem, H., Maggi, J., Nierman., D., Rolnitzky, L., Bell, D., Rennert, R., Golinka, M., Yan, A., Lyder, C., & Vladeck, B. (2010). High cost of stage IV pressure ulcers. The American Journal of Surgery, 200, 473-477.

[10] Calianno, C. (2007a). Quality Improvement Strategies to Prevent Pressure Ulcers. The Nurse Practitioner 32(7),10-15.38

[11] Russo A, Steiner C, Spector W. Hospitalizations Related to Pressure Ulcers among Adults 18 Years and. 2008;(64):1–9.

[12] Gefen A. How Much Time Does it Take to Get a Pressure Ulcer? Integrated Evidence from Human, Animal, and In Vitro StudieOstomy Wound Management. 2008;54(10):26–35. [Pub Med]