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Machine Learning Models Predicting the Survival of Abrupt Heart Attack in Cardiac Sarcoidosis Disease using the Wearable Device

Jana Shafi, P. Venkata Krishna

Abstract*: Wearable technology has countless prospects of remodelling healthcare establishment and also medical education. Cardiac sarcoidosis disease (CS) is a sporadic illness in which white blood cells (WBC) clusters known as granulomas, form as heart tissue. Cardiac sarcoidosis disease (CS) Patients are at high threat of ventricular tachycardia or ventricular fibrillation (VT/VF). Wearable cardioverter defibrillator device is introduced which helps to alleviate the abrupt heart attack risk amid patients of cardiac sarcoidosis. A reflective evaluation of the commercial record acknowledged patients of cardiac sarcoidosis disease who sported the wearable cardioverter defibrillator (WCD). ML models are applied to get accurate predictions to motivate WCD wear ability. The wearable device cardioverter defibrillator (WCD) was worn by forty six patients of cardiac sarcoidosis disease in which 22(48%) female, male 24 (52%). The wearable cardioverter defibrillator (WCD) was sported hours about 23.6 median daily. Nearby eleven ventricular tachycardia or ventricular fibrillation (VT/VF) incidents occur in ten patients (22%). Ventricular tachycardia or ventricular fibrillation (VT/VF) happened over a series of (1-79) days, median of twenty-four days. 1st- heart attack success for ventricular tachycardia or ventricular fibrillation (VT/VF) conversion was hundred percent. Survival of Patient in twenty four hours after treatment of attack was hundred percent. To regulate the discontinuing cause for wearable device cardioverter defibrillator (WCD) use specified that among seven attacked patients received ICD, one patient was died two weeks later discontinuing the use of wearable cardioverter defibrillator device (WCD), and two patients were absent to track. Sixteen were not attacked patients, who obtained an implantable cardioverter defibrillator (ICD) while seven of them attained and improved left ventricular ejection fraction (LVEF). Abrupt heart attack (HA) management amongst patients of cardiac sarcoidosis disease (CS) was assisted by wearable device cardioverter defibrillator (WCD) ensuing in positive ventricular tachycardia or ventricular fibrillation (VT/VF) termination upon attack delivery. In this paper, the dataset is retrieved from google dataset search and evaluated on various ML models to predict the survival of the patients Receiving ICD while wearing WCD as well as evaluating the developed model performance and to identify the best applicable model. Dataset is primarily processed and nursed to many machine learning classifiers like KNN, SVM, Perceptron, Random Forest, Decision Trees (DT), Logistic Expression, SGD, and Naïve Basis. Cross-validation is smeared, training is performed so that new machine learning models are established and verified. The outcomes found are assessed on many factors such as Accuracy, Misclassification Rate, True Positive Rate, True Negative Rate, Precision, Prevalence, False Positive rate taken to build the model. Result analysis reveals that among all the classifiers SVM and KNN best model acquiescent high and precise outcomes.

Keywords: WCD, Wearable, WIOMT, IoT, SCA,SCD, CS,HA

I. INTRODUCTION

Wearable devices are a novel upsurge of health tools in health-care [23]. The wearable device primarily works for health nursing daily. Cardiac sarcoidosis disease is detected in 2-5% of systemic sarcoidosis patients. Cardiac sarcoidosis diseases is a non-caseating systemic granulomatous sickness of anonymous etiology which in the majority disturbs the breathing system; further organic skins including liver, nerves, skin, eyes, and heart probably be distressed. The etiology remains mysterious, though sign recommends that it is the artefact of an endogenous genetic susceptibility and an anonymous antigenic stimulus [1,2]. The marketable record provided WCD data usage to assess patient wear duration days of wear and daily use hours. A day of wear understood as WCD was worn more than fifteen minutes any day. Daily hour's usage was understood as the worn hours allocated by twenty hours each day. On the 1st wear day daily hour's usage are the ratio of device wear hours and the sum of hours left on that day, regularized to twenty four hours. WCD wear of last day, due to WCD termination, daily hours use was undetermined. The wearable cardioverter defibrillator WCD accounts the programmed recognition and attack treatment of unrelenting ventricular tachycardia or ventricular fibrillation actions. A solo action was described to contain all copies of constant ventricular tachycardia or ventricular fibrillation happening inside twenty hours of the arrhythmia index. Unrelenting ventricular tachycardia or ventricular fibrillation was ventricular tachyarrhythmia durable extended than thirty secs, with VT understood as having a reliable morphology and VF described as an unreliable morphology. Data recordings of electrocardiogram (ECG) with VT lead towards VF were stated as ventricular tachycardia or ventricular fibrillation. Data records related with attack actions comprise the electrocardiogram (ECG)

outlining encircling the occurrence, the sum of attack cures managed and whether attack stemmed in conversion. Patient Continued existence post heart attack of 24 hours was decided by telephone track up with attack healed persons, their relatives, or liable therapeutic specialists having straight information of the incident.

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***** Correspondence Author
Jana Shafi*, Research Scholar, Department of Computer and Engineering Science, SPMVV University Tirupati, A.P., India. E-mail:: janashafi09@gmail.com
P. Venkata Krishna, Department of Computer Science and Engineering, SPMVV University, Tirupati, A.P, India. (E-mail: parimalavk@gmail.com

II. BACKGROUND

Cardiac sarcoidosis disease (CS) is stated medically in five percent of patients, but an autopsy examination of cardiovascular Magnetic resonance imaging technique (MRI) case studies exposed that subclinical Cardiac sarcoidosis disease is detected in about twenty five percent patients of Western European nation's lineage and even bigger in patients of Japanese [3–10]. Although the broad progress of sarcoidosis disease is petite and positive, the diagnosis is poorer when cardiac indexes exist, as this intensifies conduction abnormalities threat and failure of heart. Amongst Cardiac sarcoidosis disease patients, the existence of ventricular tachycardia or ventricular fibrillation (VT/VF) is raised, as evinced by an incident degree of seven percent yearly of proper implantable device cardioverter defibrillator treatments [11]. A lately available case study of young Cardiac sarcoidosis disease patient has labelled the WCD use to achieve ventricular tachycardia or ventricular fibrillation and avert abrupt heart attack (HA) [12]. The limited data help with abrupt heart attack threat assumptions [13]. The present agreement report advocated that in a principal prevention set, the left ventricular ejection fraction (LVEF) must reconsider after heart fail treatment immunosuppression and optimization if shown [6]. There is considerable works backup WCD usage to accomplish HA increased risk individuals for ventricular tachycardia or ventricular fibrillation, for example afterward a new diagnosed heart failure or myocardial infarction where ICD choice is not yet suitable, or once the hazard of ventricular tachycardia or ventricular fibrillation is because of fleeting or right reasons [14]. Further patients recognized as promoting from the wearable cardioverter defibrillator WCD are contraindication for ICD device establishment: suffering patients after ICD device description experiencing extended treatment of antibiotic; patients with a inordinate threat of HA but without an absolute verdict; last phase or transplant registered heart failure patients; and brief risk for arrhythmia patients, for instance those detected with momentary myocarditis [14–16]. WCD device effectiveness has been assessed in numerous journals. In two United States based lessons comprising numbers of 3,569 plus 8,453 focuses the VT/VF events of WCD converted 99% and 91%, correspondingly [17,18]. Newly a unit from the country of Germany comprising 6,043 subjects, and indicating the first examination of an enormous unit external of the United States healthcare structure, as well exhibited how WCD stay efficient in transforming 94% of VT/VF actions [19]. Though, corticosteroids effect on VT/VF is not steady, [8].The CS diagnosis among patients is sometimes hard. As the endomyocardial biopsy sensitivity is low (<25%) [5].A countrywide study in the country of Finland stated that the yearly CS detection rate has enlarged >20 fold over a period of 25 year [22]. Additional study exhibited that the myocardial scar presence recognized via late gadolinium improvement by MRI [4].

The present study was accomplished in order to predict survival of the CS suffering patients using WCD with the help of ML models. The paper used WCD wear dataset to examine the features and results of 46 concern patients.

III. PATIENT SUMMARY AND MEDICAL FEATURES

Cardiac sarcoidosis disease (CS) suffering patients (46) who were set and wore the wearable cardioverter defibrillator device in order to cope with the threat of VT/ VF were recognized. Table 1 précises the patient by statistics in age, sexual category, related comorbidity and LVEF. Out of 46, ten patients who remained cured for ventricular tachycardia or ventricular fibrillation while wearing the wearable cardioverter defibrillator (WCD). Contrast of patients who were traumatized versus those not attacked exposed alike circulations of age and gender. Patients offered co-morbidities generally allied with Cardiac sarcoidosis. LVEF evaluation in the beginning of WCD device use is around thirty percent. Comparatively, other attribute accounted at the commencement of wearable cardioverter defibrillator device use, the initial LVEF varied when healed and not treated patients were associated with values of twenty one percent and forty eight percent, correspondingly .Table 2 précises WCD usage in days of device garb and hourly regular usage wear also the cause for withdrawal of the WCD. LVEF Improvement was noted for 7 (19%) patients of the not attacked patients. In general Cardiac sarcoidosis disease (CS) patients, there were 3 (7%) patients deceases, though, no decease happened during the use of WCD.

Table I: Baseline parameters of CS patients

	Total Patients(46)	Prone to Attack Male=10 Female= 4	Non –attack prone Male=36 Female= 18
Male	24(52%)	6(60%)	18(50%)
Congestive Heart Failure	22(48%)	7(70%)	15(42%)
Ventricular Arrhythmia	19(41%)	4(40%)	15(42%)
Syncope	15(33%)	2(20%)	13(36%)
Heart Block	8(17%)	1(10%)	7(19%)
Coronary Artery Disease	5(11%)	2(20%	3(8%)
Female	22(48%)	3(14%)	19(86%)
Congestive Heart Failure	7(31%)	2(50%)	6(31%)
Ventricular Arrhythmia	9(40%)	2(50%)	8(42%)
Syncope	8(36%)	2(100%)	7(36%)
Heart Block	2(9%)	1(25%)	2(10%)
Coronary Artery Disease	1(4%)	0(0%)	2(10%)

Table II. WCD Usage Results

WCD Wear	Total Patients(46)	Prone to Attack(10)	None Attack Prone(36)
Total Wear Days	33 days (median)	42(median)	33 days (median)

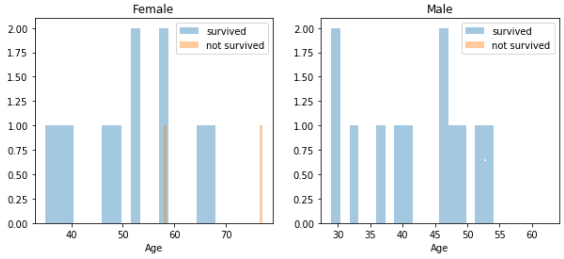
Daily Hourly Usage	**23.6 hours(median)**	**23.8(median)**	**23.3 hours(median)**
Survival Results			
Received ICD	**23(50%)**	**7(70%)**	**16(44%)**
Improved LVEF	**7(15%)**	**0(0%)**	**7(19%)**
Demise	**3(7%)**	**1(10%)**	**2(6%)**
Other	**13(28%)**	**2(20%)**	**11(31%)**

IV. METHODS AND RESULTS

A. Visualization in Python /Data Exploration

88.4% out of the dataset is survived the Sudden Cardiac Arrest. Here different attributes can be explored as follows.

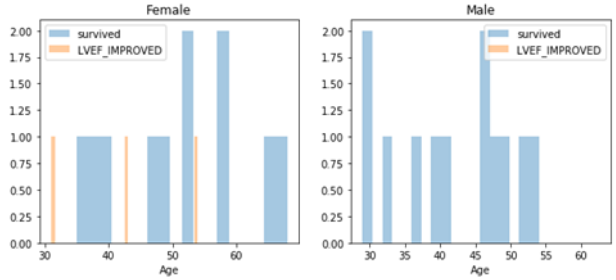
1. Age and Gender



- Men have a high chance of survival when they are between 25 and 30 years old, 46 and 47 years old, which is also a slight correct for women but not completely.
- Women survival chances are higher between 53 and 59.
- Men chance of survival is very low between the age of 32 and above 43, 47 and 53.
- Women chance of survival is very low between the age of 32 and above 40, 65 and 68.
- For women deceased at 59 and above 75 age

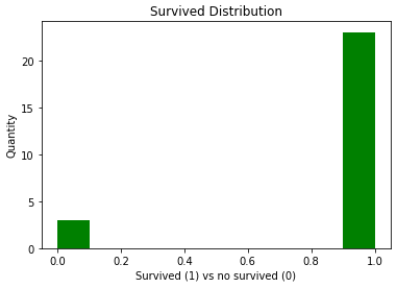
2. Survived and LVEF improved

Lvef improved and survived 70% of age between 32 and 56 in female.



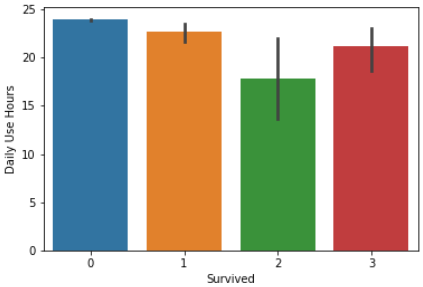
3. Survived and Received ICD

4. Received ICD and survived 88 % of age between 32 and 56 in female.



5. Wearable cardioverter defibrillator (WCD) Usage.

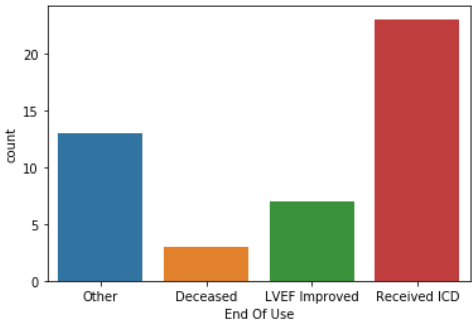
WCD daily hourly use and survival Daily use hours -23.6%



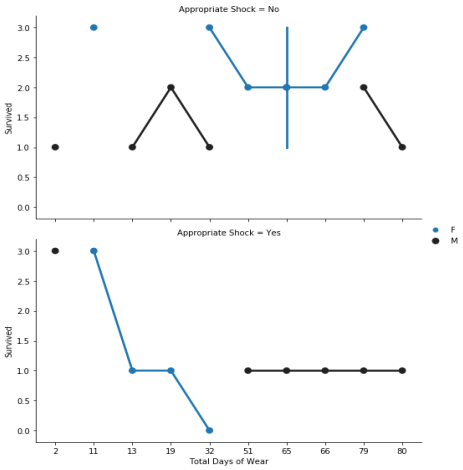
- 0-Received ICD – high survival rate for using maximum usage
- 1-Deceased – less
- 2-LVEF Improved –luckily improved
- 3-Other non-cardiac cases

6. WCD outcomes

- Received ICD 50%
- Deceased 7%
- LVEF Improved 15%
- Other 28%



7. Appropriate Attack , Survived, Gender



Appropriate attack can be understood as associated with survival of patients, dependent on the gender.

- Male with appropriate attack = No have a higher chance of survival below.
- Female with appropriate attack = No and appropriate attack = Yes have a both less chance of survival.

B. Method: Machine Learning Models

In this section, several Machine Learning models are evaluated and compare to find the best one. We are taking in account Survival as dependent on Received ICD while wearing WCD.

1. Machine Learning Model Best Model Score for Received ICD.

Score	Model
100.00	Support Vector Machines
100.00	Logistic Regression
100.00	Random Forest
100.00	Decision Tree
88.46	KNN
88.46	Perceptron
88.46	Stochastic Gradient Decent
73.08	Naive Bayes

As we can see the ML models SVM , Logistic Regression , Random Forest, Decision Tree are providing 100 % score which comes under over fit criteria and it is not accurate. **KNN model is 88.46 % perfect model for our dataset.**

2. Support vector Machine Cross Validation

The SVM support vector machine gives us an accuracy score of 85.71% on the testing data but 100% on training set. This is an indicator of over-fitting so **Min Max Scaler implemented**. The features lying in SVM require the features to vary on a similar scale. To re-scale the Received ICD data so that all features will be the same scale approximately. The MinMaxScaler technique alters features by scaling each feature to a given range. Meaning of this estimator scales and renders each feature individually such that it is in the given range on the training set.

- SVM training set accuracy: 0.8947
- SVM machine testing set accuracy: 0.8571

It improved the training and testing data by scaling each feature in the given range.

3. After cross validating Random Forest also it improved the performance by 88.49 score.

4. KNN Model is used for evaluating Confusion Matrix.88.49%

C. Result Analysis

- **Accuracy:** Overall, how often is the classifier correct? 88.49%
- **Misclassification Rate:** Overall, how often is it wrong? 1.1%
- **True Positive Rate:** When it's actually yes, how often does it predict yes? 100%
- **False Positive Rate:** When it's actually no, how often does it predict yes?100%
- **True Negative Rate:** When it's actually no, how often does it predict no?100%
- **Precision:** When it predicts yes, how often is it correct? 88.4%
- **Prevalence:** How often does the yes condition actually occur in our sample?88.4%

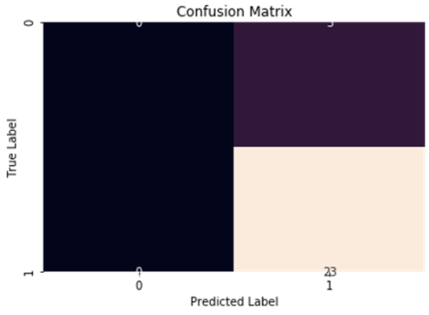
Table 3 ML Models Evaluation Scale

Model	Score	Mean	Standard Deviation
SGD	0.5	0.85	0.2
Logistic Regression	1	1	0
KNN	0.75	0.92	0.1
Gaussian	0.5	0.62	0.3
Perceptron	0.75	0.9	0.16
Linear SVC	1	1	0
Decision Tree	0.25	0.85	0.25
Random Forest	1	1	0
SVM	0.6	0.93	0.13

D. Survival Prediction: Confusion Matrix

- Predicted not survived= 0%
- Predicted Survived=26(100)%
- Actual Not survived =3(11.5%)
- Actual survived =23(88%)

array([[0, 3],[0, 23]], dtype=int64)



V. DISCUSSION

The present paper is the original to predict the survival patients while receiving ICD from WCD device in a unit of CS patients. The total forty six patients detected in the WCD device file with demonstrated eleven events of ventricular tachycardia or ventricular fibrillation VT/VF happening in ten patients. The median of everyday hours WCD device garb was 23.8 and for heart attacked and not heart attacked patients is 23.3 hours. [17±20]. WCD device usage termination, implantation of ICD was achieved in fifty percent of patients. There is no study to notify the timing of LVEF re-examination [6]. Indeed units of patients with CS and ICD have additional recurrent analyses from their implanted ICDs than other sets [21].Various ML models are implemented and KNN is selected based on it score to predict the rate of survived patients which presents the significance of the wearable cardioverter defibrillator (WCD)

VI. CONCLUSIONS

Wearable technology is the rapid revolution in the field of IoT which produces various Smart wearables assisting in the whole Healthcare system. Smart wearables improved the lives of patients suffering from various diseases by assisting them with first aid and alarming the acquaintances for their emergency conditions as well it gives them the demographic view of their health deterioration or improvement.

The reflective study describes patients with a high threat of SCA persevering for at minimum the initial 79 days of use. The wearable WCD can avert HA in cardiac sarcoidosis suffering patients with recognized, or alleged, cardiac contribution until enhanced long-standing cure approaches can be accomplished. WCD Application to control cardiac sarcoidosis suffering patients needs the prospective to decrease HA erstwhile to the verdict that undying arrhythmia threat survives, also ICD device establishment stays necessary. WCD significance of saving lives cannot be denied or ignored which grows its value and the ML model prediction gives a 100% survival rate. Here it can be said that wearable cardioverter defibrillator (WCD) will be boon in the healthcare field and for the healthcare industry and will give rise to various same smart life saviours

REFERENCES

1. Iannuzzi MC, Fontana JR. Sarcoidosis: clinical presentation, immunopathogenesis, and therapeutics.
2. Pabst S, Skowasch D, GroheÂ C. Sarcoidosis. Pneumologie 2012: 66: 96±109. https://doi.org/10.1055/
3. Pizarro C, Goebel A, Dabir D, Hammerstingl C, Pabst S, GroheÂ C, et al. Cardiovascular magnetic resonance-guided diagnosis of cardiac affection in a Caucasian sarcoidosis population. Sarcoidosis Vasc Diffuse Lung Dis. 2016: 18: 325±335.
4. Greulich S, Deluigi CC, Gloekler S, Wahl A, ZuÈrn C, Kramer U, et al. CMR Imaging Predicts Death and Other Adverse Events in Suspected Cardiac Sarcoidosis. JACC Img. 2013: 6: 501±511.
5. Kusano K, Satomi K. Diagnosis and treatment of cardiac sarcoidosis. Heart 2016: 12: 184±190.
6. Birnie DH, Sauer WH, Judson MA. Consensus statement on the diagnosis and management of arrhythmias associated with cardiac sarcoidos. Heart 2016: 102: 411±414. https://doi.org/10.1136/heartjnl-2015-308708 PMID: 26743924
7. Birnie DH, Sauer WH, Bogun F, Cooper JM, Culver DA, Duvernoy CS, et al. HRS Expert Consensus Statement on the diagnosis and management of arrhythmias associated with cardiac sarcoidosis. Heart Rhythm 2014: 11: 1304±1321.
8. Costabel U, Skowasch D, Pabst S, StoÈrk S, TschoÈpe C, Allewelt M, et al. Cardiac sarcoidosis: diagnostic and therapeutic algorithms. Pneumologie 2014: 68: 124±132. https://doi.org/10.1055/s-0033-1359197 PMID: 24497049
9. Silverman KJ, Hutchins GM, Bulkley BH. Cardiac sarcoid: a clinicopathologic study of 84 unselected patients with systemic sarcoidosis. Circulation 1978: 58: 1204±1211. PMID: 709777
10. Perry A, Vuitch F. Causes of death in patients with sarcoidosis. A morphologic study of 38 autopsies with clinicopathologic correlations. Arch Pathol Lab Med. 1995: 119: 167±172. PMID: 7848065
11. Kron J, Sauer W, Schuller J, Bogun F, Crawford T, Sarsam S, et al. Efficacy and safety of implantable cardiac defibrillators for treatment of ventricular arrhythmias in patients with cardiac sarcoidosis. Europace 2013: 15: 347±354. https://doi.org/10.1093/europace/eus316 PMID: 23002195
12. AndrieÂ R, Gaertner FC, Skowasch D. Prevention of abrupt heart attack by the wearable cardioverter defibrillator in a young patient with cardiac sarcoidosis. Thorax 2017: 72: 286±287. https://doi.org/10.1136/thoraxjnl-2016-208834 PMID: 27920335
13. Birnie DH, Nery PB, Ha AC, Beanlands RS. Cardiac Sarcoidosis. J Am Coll Cardiol. 2016: 68: 411±421. https://doi.org/10.1016/j.jacc.2016.03.605 PMID: 27443438
14. Adler A, Halkin A, Viskin S. Wearable cardioverter-defibrillators. Circulation 2013: 27: 854±860.
15. Klein HU, Meltendorf U, Reek S, Smid J, Kuss S, Cygankiewicz I, et al. Bridging a temporary high risk of sudden arrhythmic death. Experience with the wearable cardioverter defibrillator (WCD). Pacing Clin Electrophysiol. 2010: 33: 353±367. https://doi.org/10.1111/j.1540-8159.2009.02590.x PMID: 19889186
16. Reek S, Burri H, Roberts PR, Perings C, Epstein AE, Klein HU, et al. The wearable cardioverter-defibrillator: current technology and evolving indications. Europace 2017: 19: 335±345. https://doi.org/10.1093/europace/euw180 PMID: 27702851
17. Chung MK, Szymkiewicz SJ, Shao M, Zishiri E, Niebauer MJ, Lindsay BD, et al. Aggregate national experience with the wearable cardioverter-defibrillator: event rates, compliance, and survival. J Am Coll Cardiol. 2010: 56: 194±203. https://doi.org/10.1016/j.jacc.2010.04.016 PMID: 20620738
18. Epstein AE, Abraham WT, Bianco NR, Kern KB, Mirro M, Rao SV, et al. Wearable cardioverter-defibrillator use in patients perceived to be at high risk early post-myocardial infarction. J Am Coll Cardiol.2013: 62: 2000±2007.
19. WaÈûnig NK, GuÈnther M, Quick S, Pfluecke C, RottstaÈdt F, Szymkiewicz SJ, et al. Experience With the Wearable Cardioverter-Defibrillator in Patients at High Risk for Sudden Cardiac Death. Circulation 2016: 134: 635±643. https://doi.org/10.1161/CIRCULATIONAHA.115.019124 PMID: 27458236
20. Kao AC, Krause SW, Handa R, Karia D, Reyes G, Bianco NR, et al. Wearable defibrillator use in heart Failure (WIF) Investigators. Wearable defibrillator use in heart failure (WIF): results of a prospective registry. BMC Cardiovasc Disord. 2012: 12: 123. https://doi.org/10.1186/1471-2261-12-123 PMID: 23234574
21. Betensky BP, Tschabrunn CM, Zado ES, Goldberg LR, Marchlinski FE, Garcia FC, et al. Long-term follow- up of patients with cardiac sarcoidosis diseaseand implantable cardioverter-defibrillators. Heart Rhythm 2012: 9: 884±891.https://doi.org/10.1016/j.hrthm.2012.02.010 PMID: 22338670
22. Kandolin R, Lehtonen J, Airaksinen J, Vihinen T, Miettinen H, Ylitalo K, et al. Cardiac sarcoidosis: epidemiology, characteristics, and outcome over 25 years in a nationwide study. Circulation 2015: 131: 642±
23. Shafi, Jana and Amtul Waheed. "Role of Smart Wearable in Healthcare: Wearable Internet of Medical Things (WIoMT)." *The IoT and the Next Revolutions Automating the World.* IGI Global, 2019. 133-155. Web. 1 Feb. 2020. doi:10.4018/978-1-5225-9246-4.ch009

AUTHORS PROFILE

Jana Shafi is a P.hD scholar have numerous publications and authored book and chapters also serving as a reviewer in various journals also a member of prestigious associations. She attended numerous conferences and received best research award also..

P. Venkata Krishna currently works at the Department of Computer Science, Sri Padmavati Mahila Visvavidyalayam. Dr. Krishna does research in OperatingSystems, Computer Communications (Networks) and Computer Security and Reliability. Their current project is 'Power Modeling of Sensors for Internet of Things