ISSN (Print 0974-2115) (Online 2349-8552)
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Analysis of Chronic kidney Diseases using Bio-impedance measurement

D.K. Kamat*, Archana A. Pawar, P.M. Patil
Dept of EnTc, Sinhgad Academy of Engineering and Research Scholar SCOE, Pune, India.
***Corresponding author: E-Mail: dkkamat@gmail.com**

ABSTRACT

Chronic kidney disease (CKD) is one of the major diseases affecting human body. Many people worldwide are suffering from CKD. Some of them do not know that they are suffering from CKD until diagnosed. Diagnosis of CKD using non-invasive techniques is an important approach. This paper present a system used to measure total body water for patients suffering from chronic kidney diseases. The serum potassium concentration of the subjects is measured. It is observed that for CKD patient serum potassium concentration is greater than 6 mmol/L. In this work, we perform experiment on 16 female and 17 male suffering from CKD. AFE4300 EVM-PDK board has been used to measure the impedance of human body. A regression model has been built for chronic kidney diseases by recording age, height, sex, weight, impedance and total body water.

KEY WORDS: chronic kidney diseases (CKD), Serum potassium, AFE4300 EVM-PDK Board, Bio-impedance, Body composition analysis.

1. INTRODUCTION

Bio-impedance spectroscopy technique has been used to measure impedance of human body. It can be used to access the human body composition based on electrical characteristics of human body (Gabriel, 1996). Electrical bio-impedance is non-invasive, low cost and easy to handle technique (Yang, 2014). Body composition includes the measurement of various body composition parameters like total body water, fat mass, fat free mass, intracellular water and extracellular water. Total body water is combination of intracellular water and extracellular water separated from cellular membranes. Low frequency current flows outside the cell and high frequency current passed through the cell to measure the body composition parameters (Cole, 1968).

The demands of the healthcare systems has been raising due to aging population and increased life expectancies (Nations, 2012; Owen, 2010; Zhaurova, 2008). Chronic kidney disease is a worldwide health problem with an increasing incidence and high cost. CKD affects the regular working of kidney and hence reducing the ability to perform daily activities. The main symptoms of kidney disease include the tiredness and shortness of breath. Most people do not realize any of the symptoms because the body can tolerate even a large reduction in kidney function (Rosmani, 2015). The most common causes of CKD are diabetes mellitus, hypertension, and chronic glomerulonephritis. There are more than twenty-six million people in the United States suffer from CKD. Taiwan, Japan, Asia, North America and United States are some of the countries with CKD patients (National kidney foundation). The CKD can result in death in serious cases. The most popular method used for detecting CKD is the index of EGFR (Estimated Glomerular Filtration Rate), which is calculated by taking the parameters of density of creatinine in blood, gender and age of patients.

Background: CKD is global economic healthcare problem. In 2012, approximately 10% of the 29.7 million patients were diagnosed with CKD and costs of treatment for CKD approached $44.6 billion (United States Renal Data System, 2014). According to the National Kidney Foundation, CKD is the 9th leading cause of death in the United States (New York, 2015). The 47,000 fatalities were attributed to kidney disease in 2013, 450,000 patients required dialysis. In total 101,000 patients are waiting on a transplant list for one of 17,000 transplants performed annually (Health at a Glance, 2013). The Organization for Economic Co-operation and Development (OECD) member nations saw a 5.4% annual growth rate from 1990 to 2009 for CKD (Zhang, 2012). China estimates the prevalence of CKD at119.5million people (Singh, 2013). The National Kidney Foundation Kidney Disease Outcome Quality Initiative (KDOQI) established the standard guidelines for kidney disease classification and clinical treatment in 2002. CKD is further classified into 5 distinguishable EGFR ranges for assessment of the patient's kidney function (National Kidney Foundation, 2002). CKD defined irrespective of the original diagnosis (Haroun, 2003). Data mining is essential approach in healthcare industry used for analysis of the massive clinical data. Data mining is the process of extracting the hidden information from massive dataset. Techniques like classification, clustering, regression and association have been used in medical field to predict disease and to make decision related to the patient's treatment (Ahmed, 2016).

2. METHODS AND MATERIALS

In this work to measure the total body water of chronic kidney disease subjects, we perform experiment on 16 male and 17 female subjects. AFE4300EVM-PDK board is used to measure the human body impedance. AFE4300EVM-PDk board has ability to measure impedance at both single and multifrequency. Single Frequency measurement is performed at 50 KHz and Multifrequency measurement is performed at five different frequencies like 8 KHz, 16 KHz, 32 KHz, 64 KHz and 128 KHz. With the help of this board we can measure the various body

composition parameters directly like total body water, fat mass, fat free mass, BMI and impedance of human body by injecting the sinusoidal current into human body. Impedance is measured from AFE4300EVM-PDK board, on the basis of weight, height, age, sex, total body water and impedance. We build new equation used to measure the total body water for CKD patients.

In this work, we have used the EM-360 biochemical analyzer to measure the serum potassium concentration of human body. It is observed that for healthy subjects, serum potassium concentration is between 3.5 to 5.5 mmol/L. We also observed that for patients suffering from chronic kidney disease, the serum potassium concentration is above the 5.5 mmol/L.

3. RESULTS

Table.1, shows the measured serum potassium and impedance of 16 male and 17 female subjects. Table.2, shows the measured Impedance from AFE4300EVM-PDK board and serum potassium concentration measured from EM-360 biochemical analyzer. Total 33 subjects have participated in this work. Subjects are suffering from chronic kidney disease.

After measuring the serum potassium concentration for CKD patients, we build the relation between total body water and serum potassium concentration. Serum potassium concentration of 4 mmol/L is equivalent to 42 L total body water (TBW) (Carl Burtis, 2008). So, using this relationship and measured bio-impedance we have estimated TBW for all the subjects. The new regression equation for total body water has been built for patients suffering from chronic kidney diseases, based on measured serum potassium concentration, age, height, weight, sex and impedance of human body. Equation 1 is the total body water equation for subject suffering from chronic kidney diseases.

Table.1. Measured Impedance and Serum Potassium for male

Subjects	Impedance	Height	H2/R	Weight	Age	TBW	Serum potassium
1	494.41	165	55.07	60	25	34.41	6
2	498.54	172	59.34	76	28	41.45	6.5
3	490.72	168	57.52	64	29	38.22	6.8
4	493.66	164	54.48	72	32	38.32	6.1
5	477.64	178	66.34	76	39	41.78	6.4
6	497.62	166	55.38	73	25	39.75	6.9
7	427.64	170	67.58	64	22	39.5	6.2
8	497.17	174	60.90	70	28	40.92	6.7
9	467.51	178	67.77	69	41	40.34	6.3
10	491.69	166	56.04	72	45	37.37	6.6
11	496.48	167	56.17	66	42	36.91	6.1
12	487.58	178	64.98	70	52	39.31	6.5
13	488.60	162	53.71	48	19	35.06	7.2
14	473.67	174	63.92	68	52	37.91	6.3
15	499.81	178	63.39	72	56	39.21	6.9
16	486.78	166	56.61	65	46	36.03	6.2

Table.2. Measured Impedance and Serum Potassium for female

Subjects	Impedance	Height	H2/R	Weight	Age	TBW	Serum potassium
1	498.59	160	51.34	50	24	31.56	6.1
2	481.50	168	58.62	52	28	33.41	6.9
3	490.75	158	50.87	45	20	30.65	6.3
4	492.71	162	53.26	58	34	32.33	6.7
5	489.62	164	54.93	48	26	31.94	6.8
6	480.69	159	52.59	52	38	30.13	6.2
7	495.54	152	46.62	43	30	27.83	6.4
8	497.21	157	49.57	48	35	29.31	6.3
9	485.73	168	58.11	64	47	33.41	6.4
10	490.25	153	47.75	60	45	29.39	7.2
11	484.73	166	56.85	46	52	29.21	6.8
12	499.51	158	49.98	66	43	31.81	7.1
13	474.60	162	55.30	68	31	34.42	6.1
14	487.86	152	47.36	42	18	28.96	6.4
15	487.862	152	47.36	42	18	28.96	6.4
16	477.862	142	42.20	63	22	33.76	6.1
17	479.862	152	48.15	56	27	32.89	6.6

Table.3. Coefficients of total body water on the basis of serum potassium concentration

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	69.662	8.236		8.458	0.000
	A	-0.027	0.155	-0.049	-0.176	0.861
	B	-0.034	0.094	-0.104	-0.367	0.717
	C	0.063	0.071	0.198	0.894	0.379
	D	0.067	2.158	0.010	0.031	0.975

$$\mathrm{TBW} = 69.66 - 0.027\frac{\mathrm{H}^2}{\mathrm{R}} - 0.034\mathrm{Wt} + 0.063\mathrm{Age} + 0.067\ \mathrm{Sex}\ (1)$$

4. CONCLUSION

In this paper, we have developed a total body water equation for a patient suffering from chronic kidney diseases. The developed regression equation consists of a various anthropometric variables like age, height, weight, sex and impedance. The regression equation is based on measured values of bio-impedance and serum potassium concentration. The total body water has been estimated using serum potassium concentration measured from human blood samples. Serum potassium concentration is measured using EM-360 biochemical analyzer. The developed regression equation can be used to estimate total body water of patients suffering from chronic kidney diseases.

REFERENCES

Ahmed S, Tanzir K, Tanzeem M, Mahmood N and Rahman R, Diagnosis of kidney disease using fuzzy expert system, 8th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), Dhaka, Bangladesh, 2014, 1-8.

Carl Burtis, Edward Ashwood and David Bruns, Fundamental of clinical chemistry, Sixth edition, Saunders, an imprint of Elsevier, 2008.

Cole KS, Membranes, Ions, and Impulses, A Chapter of Classical Biophysics, University of California Press, 1968.

Gabriel S, Lau R and Gabriel C, The dielectric properties of biological tissues, II, Measurements in the frequency range 10 Hz to 20 GHz, Physics in Medicine and Biology, 41 (11), 1996, 2251–2269.

Haroun MK, Risk Factors for Chronic Kidney Disease, A Prospective Study of 23,534 Men and Women in Washington County, Maryland, Journal of the American Society of Nephrology, 14 (11), 2003, 2934-2941.

Levey AS, Coresh J, K/DOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification and Stratification, National kidney foundation, 2002.

Nations U, Population Ageing and the Non-communicable Diseases, Department of Economic and Social Affairs, United Nations, 2012.

Organization for Economic Co-operation and Development, Health at a Glance, Paris, France, 2013.

Owen N, Sparling PB and Healy GN, Sedentary Behavior: Emerging Evidence for a New Health Risk, Mayo Clinic Proceedings, 85 (12), 2010, 1138-1141.

Rosmani AF, Mazlan UH, Ibrahim AF, Zakaria DS, i-KS: Composition of Chronic Kidney Disease (CKD) Online Informational Self-Care Tool, International Conference on Computer, Communications, and Control Technology, Kuching, Malaysia, 2015, 379-383.

Singh AK, Epidemiology and risk factors of chronic kidney disease in India - results from the SEEK (Screening and Early Evaluation of Kidney Disease) study, BMC Nephrol, 114, 2013, 14.

United States Renal Data System, annual data report: An overview of the epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2014.

Yang GZ, Body Sensor networks, Second Edition, Springer, 2014.

Zhang L, Prevalence of chronic kidney disease in China: a cross-sectional survey, The Lancet, 379 (3), 2012, 815-822.

Zhaurova K, Genetic Causes of Adult-Onset Disorders, Nature Education, 1, 2008, 49.