

Change in Blood Cell Capacitance with Diseases

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Abstract: Diagnosis of diseases plays the most vital role in treatment. Moreover it is a tough task. Once the disease is identified correctly its treatment can be done accurately. Diagnosis is presently done by studying the chemical property of the blood. The authors want to attract the attention of researchers that the electrical properties of blood are equally important for early detection of diseases through this paper. The authors have observed that the capacitance of the blood changes with different diseases and they would discuss their observations in the paper. The capacitance is the ability of body to store energy due to the cellular activities in membrane. An elevated value of cell capacitance indicates the size of the cellular membranes, in contrast a decreased value of capacitance of living cell has lower amount of energy stored in cellular membrane. It should be noted that the blood contents changes with diseases. The variation in blood constituents changes the dielectric property of blood. As a result the membrane capacitance varies with different diseases and its value is plays an important role in the diagnosis of diseases. The blood capacitance changes in diseases like diabetes, cancer and renal failure. This paper discusses the importance of electrical property of blood in diagnosing the many diseases. Copyright © 2016 IFSA Publishing, S. L.

Keywords: Dielectric property of blood, Capacitance of cell, Diseases, Cellular membrane, Cancer, Diabetes, Renal failure.

1. Introduction

Cells are the basic units of living things. All cell membranes are bounded with a concentrated solution of chemicals and salts. Living cells make groups to perform specific functions and are connected and controlled by a sensitive communication system [1]. They balance the concentration gradient of ions between the extracellular and intracellular membrane spaces. Due to the concentration gradient a potential difference is created between the membranes. The potential difference is important for cell survival. The electrical gradient is necessary for the transportation of nutrients, oxygen and carbon dioxide. Therefore, the cell membrane has electrically insulating quantities with the capability of storing energy which is called capacitance. The membrane capacitance will

change depending on the health and the number of cells [2, 3].

2. Disease Dependant Cell Capacitance of Cell Membrane

Diseases like diabetes, cancer, and renal failure affects the blood capacitance. These diseases change the blood composition therefore changing the dielectric property of the blood. As a result the blood capacitance also changes.

Cancer: Cancerous cells show a very different dielectric property than that of normal cell. Healthy cells maintain a large range of potassium and a small range of sodium inside them. Cancerous cells have tremendous amount of salt like sodium and water flows in to the cells while minerals like potassium,

magnesium, calcium and zinc are dissipated from the interior of cell. It results in fall in potential of cell membrane [4]. Cancer changes the composition of cell membrane, membrane function, and concentrations of minerals. It also affects the potential of cell membrane and the electrical connectivity within the cells. Cancer cells produce cellular energy less efficiently [5]. Malignant cells are absolutely different in their electrical properties and have a different distribution of electrical charges. Cancer cells are having different permeability which results in flow of potassium, magnesium and calcium out of the cell. Cell membrane starts leaking. Also the membrane potential in a cancer cell is weaker than the membrane potential of a healthy cell. The electrical field which is present in the cell membrane of a malignant cell gets reduced. The reduction in the cell membrane electrical field strength results in the variation in the metabolic functions of the cell. This variation is responsible for rise in electrical conductivity and permittivity of malignant tissues. As cancerous cell shows greater permittivity, the ability to resist the formation of an electrical field is different from normal cells. The electrical conductivity and permittivity of living cell in electrical field will vary depending on the frequency applied [6, 7]. A graph between capacitance ratio (C_1/C_2) and frequency is obtained as shown in the Figs. 1 and 2. Where C_1 is the capacitance which is measured without any tissue in the dielectric and C_2 is the capacitance measured with malignant/non malignant tissues. The first curve is for malignant cell whereas the second curve is obtained when nonmalignant cell is dissolved with the dielectric.

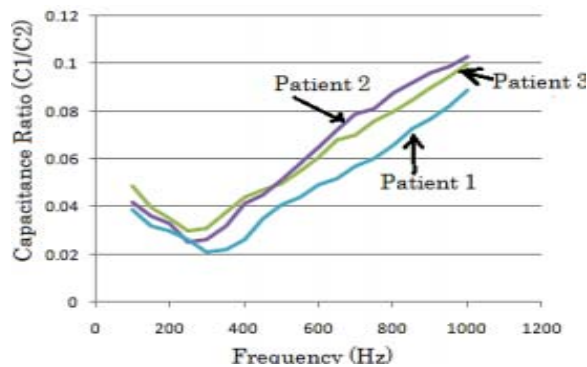


Fig. 1. Frequency Response of malignant cell.

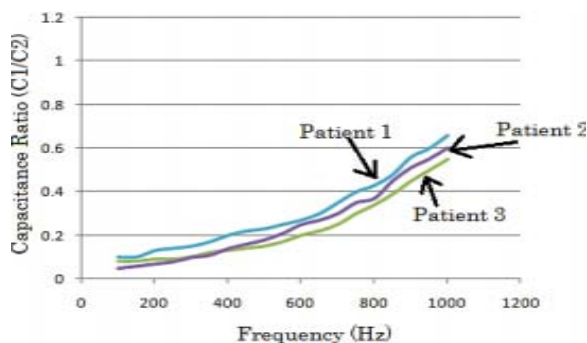


Fig. 2. Frequency response of non malignant cell.

3. Diabetes

A noticeable change has been observed in the blood capacitance with variation in blood glucose content. The experiment was carried out on 65 diabetic blood samples. The samples were collected from patients between the age group of 45 to 55 years of age. In fasting the normal range of blood sugar is 70 to 100 dg/dl and 2 hours after eating its normal range is maximum upto 140mg/dL [8-11]. The blood sample of each person has been taken at various time intervals in a day. The observations have been plotted in Fig. 3. The blood glucose was measured using glucose meter (one touch) and immediately the capacitance was measured using smart tweezers. Also the value of capacitance of each sample was measured using LCR meter at different frequencies. The curve is shown in Figs. 3, 4 and 5.

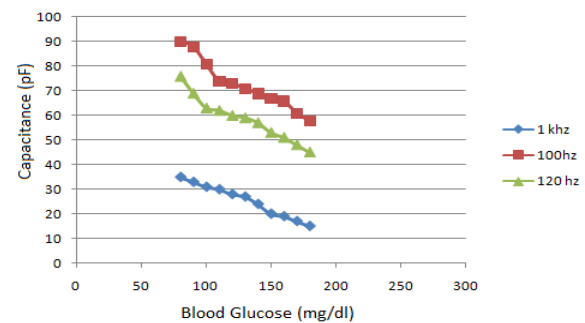


Fig. 3. Capacitance Vs Glucose curve of Person 1 (normal).

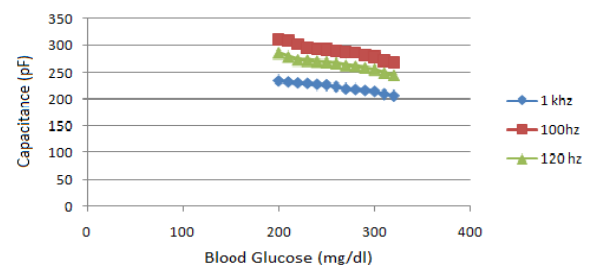


Fig. 4. Capacitance Vs Glucose of Person 2 (Diabetic).

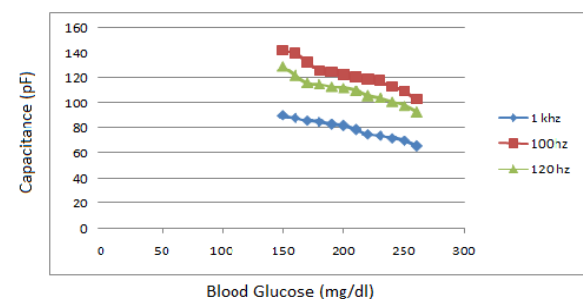


Fig. 5. Capacitance Vs Glucose of Person 3 (Diabetic).

From the above observations it is clear that the blood capacitance decreases with increase in glucose

contents. This is because as the glucose increases the dielectric property decreases which further results in lowering of capacitance values. Patients with high diabetes have low capacitance. During the research work out of 65 persons under observation, 4 died because of high diabetes and had very low blood capacitance value. Diabetes has many severe side effects which lead to deaths.

4. Renal Failure

The function of kidney is to filter the blood. Due to the kidney disorder the blood impurity increases. These impurities are called creatinine which changes the electrical properties of blood. To minimize these creatinine values patients are gone through dialysis procedure. Dialysis is an artificial kidney outside the body which is used to minimize the creatinine [12, 13]. Samples of 42 patients were collected from GTB hospital New Delhi. Blood samples of each patient were taken two times. The first sample was collected before dialysis and the second sample was taken after dialysis. The pre dialysis samples contained more creatinine than that in post dialysis blood samples. The dielectric of each samples with respect to the change in frequency were measured using DAK dielectric measurement kit.

Figs. 6, 7 and 8 shows the relationship between frequencies on the dielectric change in patient 1 with pre dialysis creatinine value 9 mg/dl and post dialysis creatinine value 5.4 mg/dl.

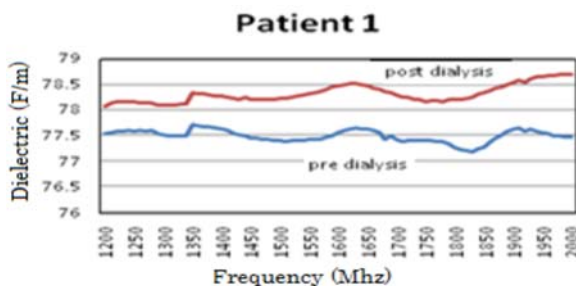


Fig. 6. Effect of variation of frequencies on the dielectric change in patient1.

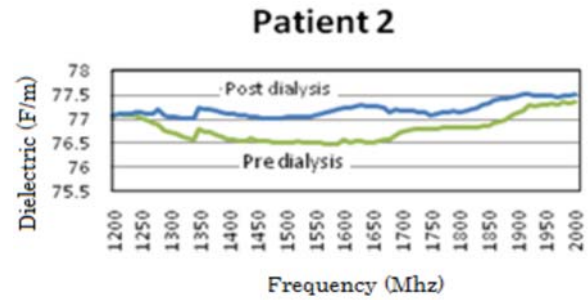


Fig. 7. Change in Dielectric with Frequency of Patient 2.

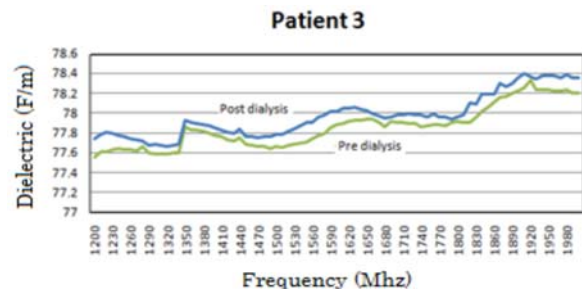


Fig. 8. Change in Dielectric with Frequency of Patient 3.

Table 1 illustrates the variations in dielectric constant of pre and post dialysis blood with the value of creatinine.

The relation between creatinine and blood capacitance is shown in Fig. 9. It is clear from the graph that as the creatinine level increases the blood capacitance decreases. The readings have been shown in Table 2.

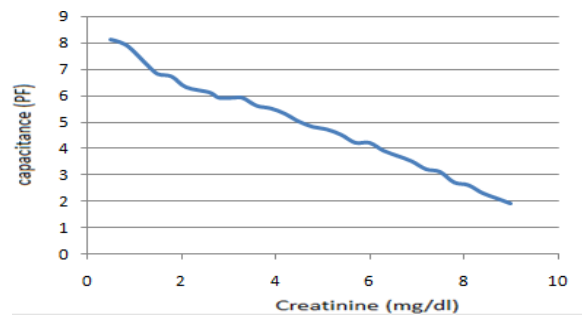


Fig. 9. Relation between Creatinine and Capacitance.

Table 1. The change in dielectric with creatinine.

Frequency Range (MHz)/ parameter	Dielectric of Patient 1		Dielectric of Patient 2		Dielectric of Patient 3	
	Pre dialysis	Post dialysis	Pre dialysis	Post dialysis	Pre dialysis	Post dialysis
Creatinine (mg/dl)	9	5.4	6.3	3.85	6.79	4.6
1200-1400	77.57	78.17	76.83	77.11	77.67	77.78
1410-1600	77.44	78.27	76.52	77.08	77.71	77.85
1610-1800	77.46	78.31	76.69	77.19	77.90	77.99
1810-2000	77.44	78.50	77.12	77.43	78.15	78.28

Table 2. Blood Capacitance with Creatinine.

Creatinine (mg/Dl)	Capacitance (Pf)
9	2
5.4	4.5
6.3	3.9
3.83	5.5
6.79	3.6
4.6	5.5

The permittivity of blood decreases with increase in creatinine level. As the permittivity is directly proportional to the blood capacitance thus as a result the blood capacitance also decreases. The dielectric of blood of same patient before dialysis and after dialysis has been measured. The blood before dialysis has more creatinine and the blood after dialysis has less creatinine. The dielectric of pre dialysis blood is less than that of post dialysis blood. This shows that the blood with less creatinine has more dielectric and hence more capacitance.

Measuring cell capacitance can distinguish between Living and Dead Cells. It is used in identifying healthy and unhealthy cells. It is one of the vital parameter which behaves as an aid in diagnosis.

5. Result

Aim of the paper is to highlight the difference between the capacitance of normal and abnormal cell. This will in turn help the society in early diagnosis of diseases so that the suffering of the patients can be minimized and they can be given better treatment. In this work common fatal diseases were studied like diabetes, cancer, renal failure, etc. It was observed that the dielectric property of blood changes with various diseases. The change has also been observed minutely and plotted carefully.

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