



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH
PHYSICS AND SPACE SCIENCE
Volume 13 Issue 7 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Measurement of Liquid Volume in Stomach Using 6-Elctorde FIM for Saline Water Intake at Periodic Intervals

By Samiron K. Saha & Pretam K. Das

Pabna University of Science and Technology, Bangladesh

Abstract- Focused Impedance Measurement (FIM) is a relatively new technique developed in the Biomedical Physics Laboratory of Dhaka University which allows improved localization of a zone without much increase in complexity of the measuring instrumentation when the electrodes are applied on the skin surface with the organs inside contributing the measurement of impedance since the body is a volume conductor. The present work is basically a preliminary study which aims at measuring the absolute volume of food or drinks of known conductivity inside a human stomach. The circuitry of a FIM system was used to study the impedance change in the stomach region of two subjects for the intake of saline (water with a little salt) with a particular conductivity on several days, each day with a different volume of the saline. It was ensured that they had the same history of food intake in the previous day and all physical conditions remain the same during the measurement for reproducibility. The impedance changes for different volumes of the saline in the one subject agreed well, and it appears that provided the correction factors mentioned above are incorporated, FIM may be used to measure the volume of food or saline in the stomach of a person.

GJSFR-A Classification : FOR Code: 029999



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Measurement of Liquid Volume in Stomach Using 6-Electrode FIM for Saline Water Intake at Periodic Intervals

Samiron K. Saha^a & Pretam K. Das^a

Abstract- Focused Impedance Measurement (FIM) is a relatively new technique developed in the Biomedical Physics Laboratory of Dhaka University which allows improved localization of a zone without much increase in complexity of the measuring instrumentation when the electrodes are applied on the skin surface with the organs inside contributing the measurement of impedance since the body is a volume conductor. The present work is basically a preliminary study which aims at measuring the absolute volume of food or drinks of known conductivity inside a human stomach. The circuitry of a FIM system was used to study the impedance change in the stomach region of two subjects for the intake of saline (water with a little salt) with a particular conductivity on several days, each day with a different volume of the saline. It was ensured that they had the same history of food intake in the previous day and all physical conditions remain the same during the measurement for reproducibility. The impedance changes for different volumes of the saline in the one subject agreed well, and it appears that provided the correction factors mentioned above are incorporated, FIM may be used to measure the volume of food or saline in the stomach of a person.

I. INTRODUCTION

Biomedical physics is a comparatively new branch of physics, which projects the application of physics in the medical science. This helps to understand the normal and diseased condition in the body and design suitable method and instruments for diagnosis and therapy. Bio-impedance techniques were born within the last century. Impedance is a characteristic property of any material, including biological materials. Different body tissues may have different electrical conductivities, and which can again vary between health and disorder. Monitoring of physiological events by impedance has become a subject matter of great interest. These techniques are only applicable for those disorders, which are located on the surface or near the surface of the human body. Images can be formed considering the variation of electrical properties that biological tissue exhibits. Biological tissue exhibits two important passive electrical properties. First, it comprises free charge carriers and

may thus be considered as an electrical conductor. Electrical conductivity is a characteristic property of different tissues and images of tissues having different electrical conductivities may resolve structure and even be indicative of pathology. Secondly, tissues also contain bound charges leading to dielectric effect and it might be possible to form an image of relative electrical permittivity. Electrical impedance is a measurement of how electricity travels through a given material. Every tissue has different electrical impedance determined by its molecular composition. Focused impedance measurement (FIM) technique, a new measurement technique with improved zone localization, was proposed and developed in Biomedical Physics laboratory of the University of Dhaka [1, 2]. In FIM technique, the impedance of the region of interest is measured from two mutually perpendicular directions simultaneously. In one method, two independent sets of four-electrode system are placed orthogonally enclosing the region for this purpose. In another, the currents in two perpendicular directions are of the same frequency, phase and amplitude but isolated from each other. By placing two potential measuring electrodes at appropriate points, a single potential measurement gives a combination of the two perpendicular measurements measured in this procedure. In this method, the central region has more contribution than the neighboring region. Therefore, focusing is expected and an experimental study was taken up to analyze this in detail.

II. THEORY

In this method impedance of the region of interest is measured from two mutually perpendicular directions simultaneously is the basis idea of the new technique. For this method two independent sets of four electrode system placed orthogonally to one another surrounding the region. Two current sources of same frequency, phase and amplitude are introduced simultaneously and resulting potentials are recorded. Impedance follows according to the Ohm's law ($Z = V/I$) where V is the combined potential and I is constant current passing through driving electrodes. The impedance of the region of interest contributes more than the neighboring regions as it is counted twice. Thus

Author α : Lecturer, Department of Physics, Pabna University of Science and Technology, Pabna-6600, Bangladesh.
email: samiron_physicist@yahoo.com

Author σ : Lecturer, Department of Physics, Pabna University of Science and Technology, Pabna-6600, Bangladesh.
email: pretam_nphy@yahoo.com

some degree of focusing on a particular region is expected to be obtained by our new technique. And as the region of interest is more focused compared to the other regions, the name has been offered to the proposed technique is Focused Impedance Method (FIM).

a) Six Electrode Fim System

The focused system basically involves two independent four electrode measurements which need

eight electrodes in all. To obtain this combined output the hardware may be simplified through some modified placement of measuring electrodes and by electrically isolating the two current drives so that they do not interact, it was possible to reduce the number of electrodes to six and to obtain the desired combined impedance through a single measurement as described below[3, 4].

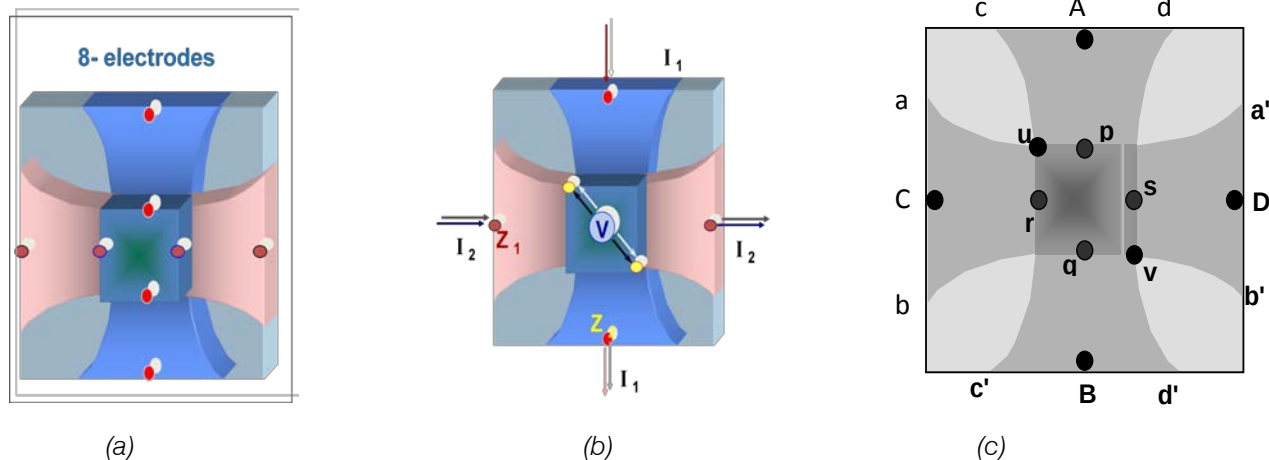


Figure 1 : Reduced six electrode FIM

Figure 1, electrode u can replace electrodes p and r for measurements in either of the perpendicular directions as it falls on the appropriate equipotentials aa' and cc' respectively. Similarly, electrode v can replace electrodes q and s for similar measurements. Now if the alternating currents through electrodes AB and CD can be made to have the same frequency, magnitude and phase but electrically isolated, the potential measured across uv will be directly proportional to the sum of the individual four electrode impedances. Thus the number

of electrodes is reduced to six from eight and only one potential measurement circuitry is needed instead of the expected two (considering two separate four electrode measurements). The prototype was designed and fabricated following this concept as described below.

b) Instrumentation For Six Electrode Fim

A block diagram of necessary instrumentation developed for the FIM is shown in Figure 2 [5].

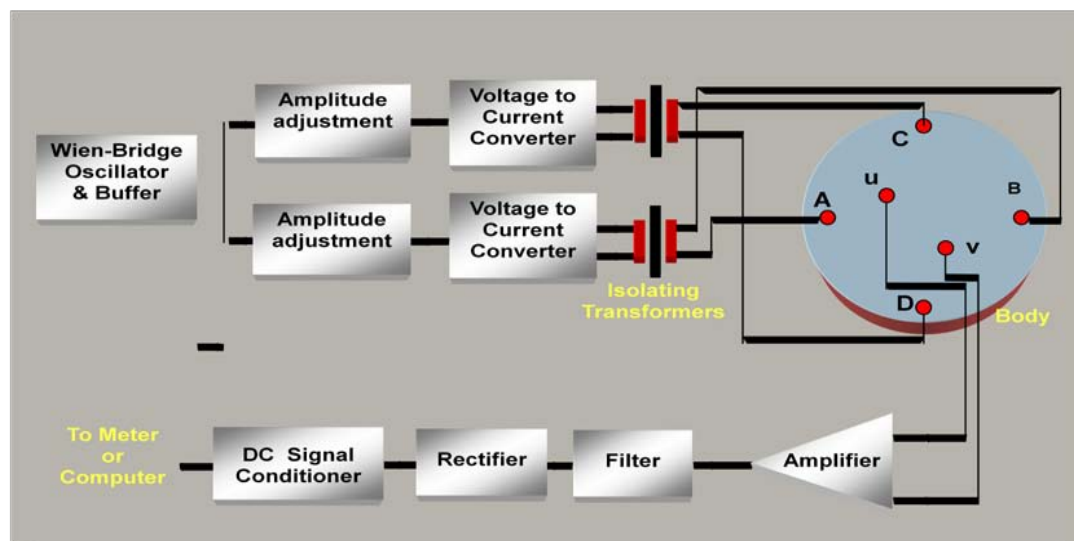


Figure 2 : A block diagram of the 6-electrode FIM

A sinusoidal signal at about 10 kHz is generated using a Wien Bridge oscillator. This is branched out to two isolated current drives (AB and CD) through appropriate voltage to current converters and isolating transformers. The necessary electrode connections are shown on a circular body. The current drives may be set in the same phase or in the opposite phase by simply reversing the electrode connections from one of the two isolating transformers. Since the two isolating transformers may not be exactly equal, two amplitude adjusting circuitry as shown were introduced to make the two perpendicular driving currents the same. The combined impedance measurement (sum) is carried out through measuring the potentials between electrodes u and v. The measured potential is amplified, filtered, rectified and smoothed out to obtain a dc voltage which is proportional to the combined impedance. This dc output voltage may be measured using a digital voltmeter for manual work or may be fed to a computer for automated data acquisition. [Rabbani, 1994].

III. RESULT AND DISCUSSION

For human subjects the depth of the stomach and the resistivity of liquids within them are approximately known (blood, acid, urine respectfully) although the last one may vary depending on the water intake by the subject. If these two parameters are assumed to remain constant then the volume may be measured too.

a) Measurement Made on Human Objects

All collected data are shown graphically in the following figures to have the understanding of measuring liquid volume in stomach by using 6-electrode FIM system and we tried to collect result and discussion from these graphs.

a. Variation of impedance in empty stomach

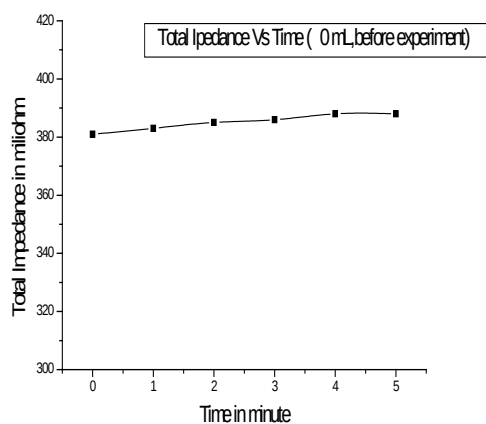


Figure : 3

From the fig.3 we see that in empty stomach the total impedance was approximately, the same i.e. did

not change of time. Since the content of the stomach did not change, its impedance also did not, as expected. The slight increase of the impedance may be attributed to the change of position of the stomach and other experimental errors.

b. Variation of impedance with repeated saline intake in the stomach

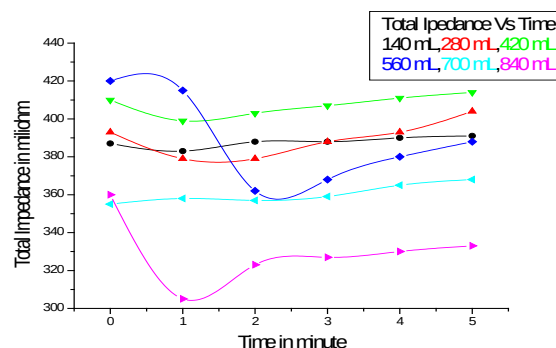


Figure : 4

From the fig.4 above, we see that after the subjects had a drink of water with a little salt the total impedance decreased immediately. Gradually the total impedance increased with the passage of time. When the subjects had a drink of water the position of stomach may have changed. It is also possible that we could not have changed the position of the electrodes correctly to compensate the change of the position of the stomach. The reading of multi-meter fluctuated slightly which resulted in an error in the measurement of the impedance.

b) Repeated Drink by a Human Subject

The following graph shows the variation in impedance-value when a person drank saline water repeatedly maintaining a fixed time interval of 5 minutes.

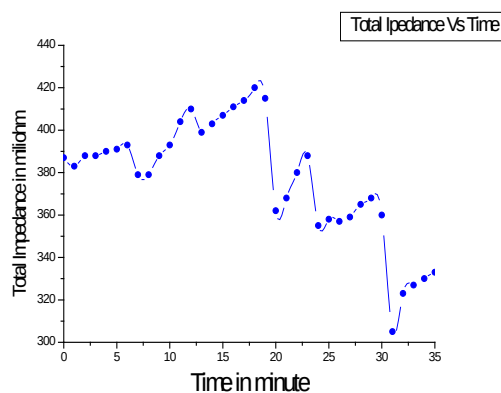


Figure : 5

Fig.5 represents the overall trend of the impedance over the total period of time. It is clear that

we got different rates of increase and decrease in the total impedance at different times. There is an overall decreasing trend for the impedance with time. Notice that, the amount of change of impedance with subsequent drinks fluctuated with time, which may be accounted for due to the unequal flow of water from the stomach into the intestine.

IV. CONCLUSION

We had human subjects drink saline water (to get an increased conductivity as compared to using pure water) and measured the electrical impedance of the region of the body where stomach is situated. The measurement probes were put on the skin and we got interesting variation of the impedance right after the drink was taken. During the measurement, subjects were asked to breathe in fully and to hold the breath so that all the measurements were reproducible. Breathing in also reduces the current through adjacent lungs as they are filled with insulting air. The subjects were kept at sitting position during the measurements, again to obtain reproducibility. The impedance measurement on the stomach showed that intake of saline water reduces the impedance sharply. Current will flow more easily through a stomach, filled partially or fully with saline water, as its impedance is smaller than that of stomach tissue plus the air inside the stomach. Hence, the net impedance will be that of the parallel combination of a saline-filled stomach (having low impedance) and adjacent tissues (having higher impedance). Hence, the saline-filled stomach dominated in the impedance of the region. Using impedance measurement, we can easily identify an intake of water into the stomach in almost real-time. Later measurements showed a gradual increase of impedance of the region of interest where stomach is situated. The obvious reason is that, water flowing into the stomach does not remain confined within it. It continuously, albeit slowly, flows out of the stomach into the intestine. The reduction of water volume inside the stomach results in a subsequent increase of the impedance value. However, depending on the flow into the stomach and out of it, the resultant volume of saline water may increase or decrease. The gradual decreasing trend of the impedance vs. time graph (Figure 36) implies that net volume of water inside the human subject was increasing. Besides water intake, another factor that affects the impedance is acid secreted from the walls of the stomach. Acid acts as a low impedance material and reduces the impedance of the stomach when secreted. *FIM is thus a promising technique for the study of acid secretion and has medical uses in identifying stomach diseases.* The results that we obtained for the two subjects for impedance (proportional to the output voltage, since the current is constant) change with volume of water intake appeared to agree well. However, the subjects were

both young and had a similar physical frame. We may expect wider variation of the impedance with subjects of different ages and physical build up. We could not perform measurements on more than three subjects due to shortage of time. During the measurements, the stomach did not remain at the same depth in different human bodies. It also does not remain static; rather it moves constantly. If the electrode distance is comparatively less and stomach remains at greater depth than electrode distance, then we will obtain less sensitivity and zone localization becomes arduous. The present work on sensitivity variation and on local impedance measurement of human body have increased the confidence with which the FIM system may be applied for real life measurements on human subjects for physiological studies and for diagnosis of disorders such as cancer cell – identification, post heart attack, kidney, skin disease identification etc.. In this respect, our work has passed the way for future application of FIM for useful medical purposes.

V. ACKNOWLEDGEMENT

In preparation of this work I must acknowledge at the very outset the contributions of many people in varied ways. I am extremely delighted to express my deepest sense of gratitude and indebtedness to my respected teacher, Golam Dastagir Al-Quaderi, Associate professor, Department of Physics, University of Dhaka, Bangladesh, for their constant supervision, suggestions and encouragement throughout the progress of my work that helped me to complete this work. The most significant contribution, for which I shall remain forever grateful, is that of my teacher, Dr. Khondkar Siddique-e-Rabbani, Professor and Chairperson of Department of Biomedical Physics & Technology. His consistent encouragement, continuous guidance, numerous suggestions and ideas throughout the experimental process as well as in the preparation of the manuscript were absolutely essential. Finally, I remember my parents, brother and sister for their love, affection and encouragement in my whole life. Above all, I remember almighty God for his grace which allowed me to complete this thesis successfully.

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