

QUANTITATIVE CORRELATION OF BIOELECTRIC IMPEDANCE  
WITH PHYSIOLOGICAL PARAMETERS

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Thesis submitted to the Indian Institute of Technology, Delhi,  
in partial fulfilment of the requirements for the degree of  
Doctor of Philosophy

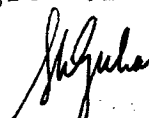
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CERTIFICATE

This is to certify that the thesis entitled "QUANTITATIVE CORRELATION OF BIOELECTRIC IMPEDANCE WITH PHYSIOLOGICAL PARAMETERS" being submitted by Mr. Mahfoozur Rahman Khan to the Indian Institute of Technology, Delhi, in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy of the Indian Institute of Technology, Delhi, is a record of bonafide research work carried out by him under my supervision and guidance for the last three years and to my knowledge it has reached the standard fulfilling the requirements of the regulation relating to the degree.

The results contained in this thesis have not been submitted in part or in full to any other university or Institute for the award of any degree or diploma.

  
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## ACKNOWLEDGEMENTS


The author wishes to express his gratitude to his supervisor, Professor Sujoy K. Guha for his valuable guidance and encouragement during the entire course of this dissertation.

The author is grateful to Professor Sujoy B. Roy, Department of Cardiology, All India Institute of Medical Sciences, New Delhi, for his help in carrying out the clinical studies. The help and suggestions rendered by the authors colleague Mr. S.N. Tandon are gratefully acknowledged.

Thanks are due to Professor Jalaluddin of Aligarh Muslim University for his encouragement, to the authorities of A.M.U. Aligarh for the sponsorship to conduct the research work and to the authorities of I.I.T., Delhi, and A.I.I.M.S, New Delhi for providing research facilities. Appreciation is extended to the Ministry of Education, Government of India, for the award of scholarship under Q.I.P. Scheme.

Thanks are due to all the subjects who cheerfully volunteered themselves with full cooperation for the experimental studies. The author wishes to acknowledge the debt owed to his colleagues for their help at various stages during the course of this dissertation.

The author would finally like to express his affectionate appreciation to his wife Nasreen for her patience and understanding during the course of the research work.



( Mahfoozur Rahman Khan )

ABSTRACT

The thesis deals with the methods for arriving at a quantitative correlation bioelectric impedance and physiological parameters. Electrical impedance of a segment of body as measured by passing a small current, can be related to the tissue and fluid volumes within the segment. This is the basis of electrical impedance plethysmography, a technique useful for deriving information regarding physiological variables. But clinical acceptance of the technique has been slowed probably because the theoretical base itself is not firm.

Absence of a full understanding of current flux paths inside the body has been identified as a major cause for the lacuna in past work. As a first step therefore an attempt has been made to investigate the current density distribution taking into account anatomical factors as well as the electrical properties of body tissue.

The basis for applying electromagnetic field equations to the problem of obtaining current and potential distributions inside the body has been given. Both stationary as well quasi-stationary fields can be dealt with by the formulation derived. The approximations involved in applying the equations to the thoracic region have been analysed. As the thorax is a complex structure containing several inhomogeneities with irregular boundaries, analytical solution of the field equations is not

possible. Therefore as an alternative a numerical technique is suggested. A three dimensional numerical solution of the field equations is worked out using proper boundary conditions at the surface of the body and at the interface of different internal media. Finally, suitable finite difference equations for obtaining the current density distribution and the transthoracic electrical impedance from the field distribution data have been derived.

Appropriate computer programs have been developed for determining the distribution of current densities, and the current passing through individual regions of the thorax. Results obtained from the programs have been used to identify the origin of impedance variations. Determination of the current density distribution beside leading to an understanding of the origin of impedance variations has also resulted in a quantitative relationship between transthoracic electrical impedance and the external geometrical dimensions of the thorax. The validity of the relationship has been experimentally confirmed on human subjects.

It becomes apparent from the computations of current density distribution that the transthoracic electrical impedance decreases markedly if the resistivity of lung tissue decreases. Such a situation may arise due to a pathological condition known as pulmonary oedema. In order to determine the oedema

fluid in the lungs, a theoretical plot has been obtained between transthoracic electrical impedance and intrathoracic fluid volume. The validity of the curve has been verified in cases of pulmonary oedema due to high altitude hypoxia and in confirmed cases of cardiac disorders. The curve has been suggested as means for noninvasively quantitating the pulmonary oedema fluid.

Using the experimental observation that the resistivity of all tissues inside the thorax is frequency dependent in a specific frequency range, whereas resistivity of blood remains almost constant, a method has been evolved to estimate the blood and tissue mass inside the thorax. Theoretical results have been verified in confirmed cases of ischemic heart disease.

Finally, limitations of the work and the scope of further investigations in the area are brought out.

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