A new approach to classify risk in dengue infection using bioelectrical impedance analysis

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Dengue fever was first reported in Malaya (the former name for Malaysia) after an epidemic in Penang in 1902.[1,2] Since then the disease has become endemic in the country with cases reported throughout the year. In 1998, there were 27 373 dengue cases with 58 deaths reported, as compared to 19 544 cases with 50 deaths in 1997. This has shown an increase of 7829 cases or 40.1% in one year.[3] However, the dengue haemorrhagic fever (DHF) case-fatality rate (CFR) increased to 1.7%.[4] In 2001, there was a sharp increase in dengue cases in the country according to the vector-borne disease unit of the Ministry of Health, Malaysia.[5] In 2003, the serologically confirmed dengue cases totaled 14 170, which number was slightly lower than the previous year (15 493). The CFR dropped to 4.5% as compared to 5.05% in 2002. The most deaths were seen in the 5–9-year-old age group, with adults mainly in the 20–35 years age groups. The dengue cases have seen a rise of 16% every year since 2003.[6] Fatalities related to dengue cases reached record levels in 2004, when 102 fatalities were reported.[6] In January 2005, the number of infections in parts of Malaysia rose significantly, with about 250 suspected dengue cases reported each week in Kuala Lumpur, compared to an average of 100 cases weekly in December 2003. An increase of 34.97%, representing 1416 cases, was recorded during the second week (Jan 9-15) of the year compared to the previous week (1049 cases).[7] Forty-four dengue patients died in the first four months of 2007 out of 16 214 cases reported, compared to 21 deaths and 10 244 cases in the same period last year.[6]

Due to the constantly high fatality rate, an accurate determination of the prognosis of the disease plays a very important role in the patient management, so that the high risk patients can be treated more intensively in their early phase to improve survival. A non-invasive prognostic system for dengue infection is yet to be developed and deployed in Malaysia. Due to the endemic dengue phenomenon in the country, there is a real and obvious need for such a prognostic system to be made available as soon as possible.

This paper describes a novel non-invasive approach to monitor and classify the daily risk in dengue patients using the single-frequency bioelectrical impedance technique. The research findings illustrate that any change in the value of reactance (X_C) will indicate the changes in electrical conductivity of the body and this can be used to monitor and classify the risk severity in dengue patients.

Principles of bioelectrical impedance in humans

Impedance (Z) is a measurement of the ability of a medium to conduct current. All conductive materials have impedance, including living tissues. The impedance of various organisms is known as bioelectrical impedance, which may vary seasonally, diurnally, and when stimulated with an assortment of stimuli. An example of the said stimulus includes physiological changes that occur when a body is affected by fever caused by bacterial and viral infections.

Bioelectrical impedance analysis (BIA) is the assessment of changes in electrical tissue conductivity that indicate altered body composition. The impedance of the body is made up of two components. The resistance (R) is the index of conductivity determined by energy-dissipating characteristics of the body. The reactance (X_C) is the index of conductivity determined by the energy-storing characteristics of the body.

In the healthy living body, the cell membrane consists of a layer of non-conductive lipid material sandwiched between two layers of conductive protein molecules. The structure of cell membranes makes them capacitive reactive elements which behave as capacitors when exposed to an alternating current (Figures 1a & 1b).[8] Although the total body water and extracellular water offer resistance to electrical current, only cell membranes offer capacitive reactance. Since fat tissue cells are not surrounded by cell membranes, reactance is not affected by the quantity of body fat. Typical total body BIA measurements display the vectors of resistance and reactance, which are intrinsically based on a series network of resistors and capacitors (Figure 2).

Biologically, the cell membrane functions as a selectively permeable barrier separating the intracellular and extracellular fluid compartments. It protects the interior of the cell while allowing passage of some materials to which it is permeable. The cell membrane maintains a fluid osmotic pressure and ion concentration gradient between the intracellular and extracellular compartments. This gradient creates an electrical potential difference across the membrane which is essential to cell survival. Damage to the cell membrane, and its functions, is as lethal to the cell as direct damage to the nucleus itself.

Resistance is indirectly related to the extracellular mass and reactance (X_C) is indirectly related to the intracellular mass. Low X_C, which correspond to the inability of cells to store energy and indicates of cell breakdown in selective permeability of cell membranes. On the contrary, high X_C, indicates large quantities of intact cell membranes and body cell mass.[9,10,11]

Full text is available at :