On Pneumothorax Detection in Microwave Frequencies Region

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Pneumothorax is caused by the air concentration inside the pleural cavity, the space between the lung and the chest wall. The trapped air presses the lung and affects normal respiration, drastically. Progressive build-up of pressure in the pleural space can obstruct venous return to the heart. This leads to circulatory instability and may result in traumatic arrest.

Pneumothorax is usually diagnosed by X-rays, Computed Tomography (CT) or ultrasound imaging. However, pneumothorax detection in emergency situations must be rapid and at the point of care and above methods are costly, time consuming and overall not available out of hospital. Microwave sensors can provide the solution to such cases at they could lead to a light, non invasive, low power, assistive device. The sensor could monitor differentially the reflected waves, which alter in phase and amplitude, due to the presence of air cavities close to the skin surface. Subject has been visited previously but not addressed in total.

The dominant biological tissues in the thorax section are: skin, fat, muscle and bone. Inter-subject variability reasons, such as gender; weight; height; obese factor; fitness factor can influence the thickness of mainly fat and muscle layers. Therefore a sensor should be able to deal with such uncertainties and in the same time provide an estimation for the situation severity. Several parameters need to be dealt with, like the frequency band, the antenna type employed, the number of antenna elements used.

This work attempts to establish a method that can lead to pneumothorax detections and quantification, at microwaves regions. It starts with a preparatory phase order to assess the interaction between a planar layered tissue model of thoracic area and one or multiple microwave sources. The variations in reflection coefficient and reflected electric field define the operational frequency band of the sensor. For simplicity, we preselect to use only two microwave sources for which S21 is recorded. Sources vary between waveguides, planar patch antennas and vivaldi type antennas. Cases examined vary from multilayered rectangular thoracic phantoms to realistic MRI anatomical models. Sex-related anatomical differences are taken into account in MRI-based models. In rectangular models, thickness and configuration of muscle, fat and bone tissues are varied, according to literature. It is important to notice that measurements will be presented; first for canonical phantoms and then for guinea pigs at which pneumothorax has been artificially induced.

As seen from the multitude of results presented pneumothorax detection is feasible, however quantification of air cavity (and therefore severity of the case) is not always easy to determine and further steps need to be taken. Further discussion on issues concerning accuracy and limitations of the current method will be discussed. Also, possible future steps on increasing the number of elements and combined information from frequency and time domain will be addressed.