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Time Domain Analysis of Phonocardiographic Signals in Response to Cardinal Vowels

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***Abstract*—**Sound travels as a mechanical wave through the material mediums. Speech is also a sound wave and used to communicate intent, ideas, and desires. Sound waves are widely used in various applications of mechanical, electrical, civil, industrial, and medical engineering. In medical treatments, sound in the form of ultrasound waves has been successfully used for detecting the problems in the human body by imaging the internal details of the organs. Ultrasound systems operate in 2 MHz to 20 MHz range, although some systems are approaching 40 MHz as well. Ultrasound images are generated using the reflected sound waves from the boundaries of different organs falling in the path.

Although ultrasound imaging is widely used for detecting abnormalities in the organs, the technique has several drawbacks in the amount of cost and time involved for the tests. Further, the high frequency waves are diffracted very easily and it becomes difficult to detect the problems of the deeper organs. The objective of this paper is to investigate the information content of the human sounds recorded from different external sites around the heart over the human body for detecting medical anomalies. Investigations were carried out with the recorded sounds on the heart corresponding to the three cardinal vowels for four male and four female subjects. The recording and analysis of the results showed that the shapes of the signals recorded on female heart are different as compared to that of male subjects. Hence, the results may be useful for medical predictions for better understanding of the medical problems.

***Keywords*—**Spectral analysis; spectrogram; visual ananysis.

I. INTRODUCTION

Sound travels as a mechanical wave through the material mediums. Sometimes sound refers to only those vibrations with frequencies that are audible to human beings or other living animals. Speech is also a sound wave that is considered as natural and efficient means of communication among human beings. It is usually considered as a sequence of discrete entities or segments. The production of speech is a physical process but its perception is a signal that has been recognized by the human brain [1]. The information contained in the spoken sound is transmitted in the form of speech signal.

Different parts of body are involved in the generation of speech that include diaphragm, lungs, wind pipe, vocal folds, epiglottis, velum, tongue, teeth, lips, and nasal cavity. The process of speaking is initiated in the brain and signals are passed to these organs in a coordinated fashion. The diaphragm moves upwards due to which pressure is increased inside the lungs. When the lungs pressure becomes greater than the atmospheric pressure, the air starts to move from lungs towards the lips. Pressure then drops due to the high velocity of moving air inside the vocal folds. The vocal folds start moving because of Bernoulli's principle and elasticity resulting in sustained oscillations. The frequency of vibration of the vocal folds is called the pitch frequency that is normally in the range of 100 Hz to 600 Hz depending upon weather the speaker is a male female, or a child. By modulating the shape of the vocal tract, different types of sounds ranging from vowels to consonants may be produced [2].

Different types of devices are already available in market for sound detection. These sound detectors are used in military and defense sector, law enforcement agency, baby monitoring systems etc [3]. Sound waves have also been used for determining the depth of water and length and school size of the fish.

There are other sound waves which have higher frequency than the audible sounds, called as ultrasound waves. Ultrasound waves are widely used in numerous industrial and medical applications. Ultrasound imaging is widely used in cardiology, obstetrics, gynecology, abdominal imaging, etc. Ultrasound systems operate in 2 MHz to 20 MHz range [4]. Ultrasound waves may be used to view different regions of the body like chest, abdomen, pelvis, and so on.

Ultrasonic is the application of ultrasound. At higher power levels, ultrasonics is useful for changing the chemical properties of substances [5]. Another important application of ultrasonic is to detect faults and cracks in pipelines [6]. Ultrasonic devices are used to detect objects and measure distances. Lung ultrasound has a higher diagnostic accuracy for pleural effusion, consolidation, and interstitial syndrome [7].

Although ultrasound imaging is widely used for detecting abnormalities in the organs, the technique has several drawbacks in the amount of cost and time involved for the tests. Further, the high frequency waves are diffracted very easily and it becomes difficult to detect the problems in the deeper organs.

The objective of this paper is to investigate the effect of sounds corresponding to the cardinal vowels /a/, /e/, /u/ on the shape of the recorded sounds on heart.

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II. METHODOLOGY

For the proposed investigation, the recording was carried out with eight subjects, four males and four females. The recording of the sound patterns was carried out on the heart at one position named as A1 corresponding to the cardinal vowel.

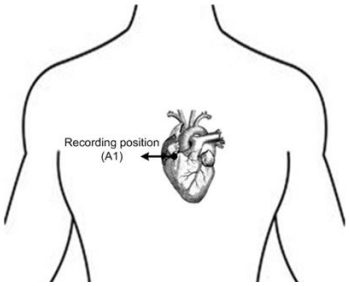

Fig. 1. Indicating recording position on the heart.

Subject will be requested to lay down in sleeping posture.

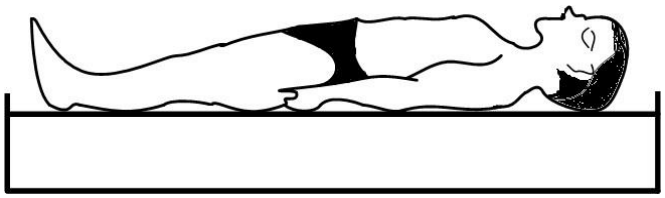

Fig. 2. Sleeping Posture.

The recordings are taken using low frequency sound waves on the basis of:

a. Effect of sound waves corresponding to cardinal vowel /a/ on the shape of the recorded sounds on the heart.

b. Effect of sound waves corresponding to cardinal vowel /e/ on the shape of the recorded sounds on the heart

c. Effect of sound waves corresponding to cardinal vowel /u/ on the shape of the recorded sounds on the heart

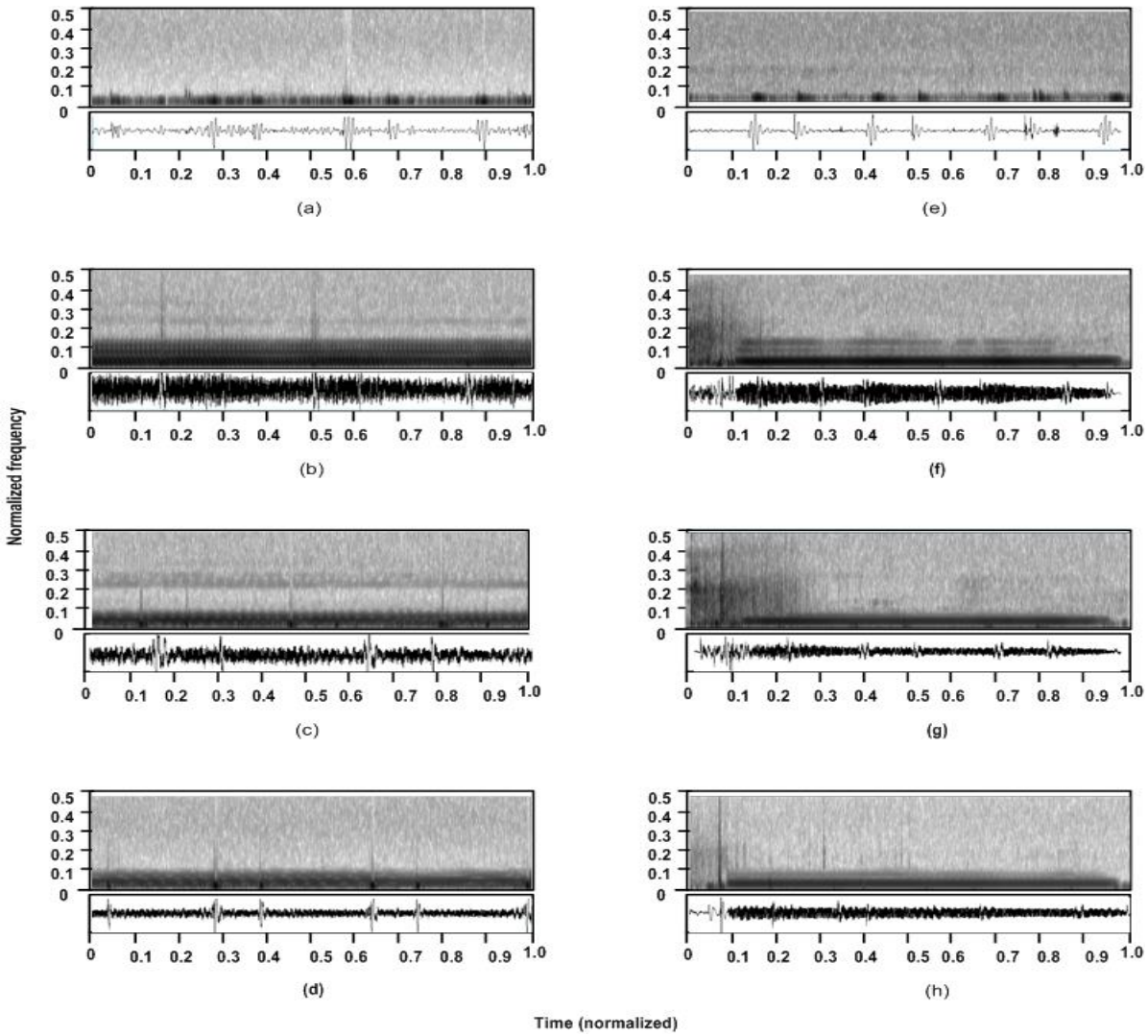

Fig. 3. Recorded signals on the heart and their spectrograms corresponding to silence and cardinal vowels /a/, /e/, and /u/.First column is signals of a male subject and second column is signals of a female subject. (a, e) silence, (b, f) /a/, (c, g) /e/, (d, h) /u/.

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Once the signals are recorded inside the computer memory, different types of algorithms such as ICA (Independent Component Analysis) and Weiner filtering will be applied to extract different sources responsible for generating the recorded vibration patterns.

III. Results and Discussion

Figure 3 shows the time domain signals recorded on the heart and their spectrograms corresponding to silence, /a/, /e/ and /u/ by a male and the female subjects.
Column 1 shows the signals for a male subject and column 2 shows female subject.

Figure (a-e) are for silence, hence heart sounds are clearly visible in the figures. The only small differences are observed in the time domain variations of these sounds for male and female subjects. In case of female subject, relatively more modulation was observed for all the three cardinal vowels. This may be due to the presence of female specific organs in the vicinity of the heart. Therefore, the shape and spectral components of the recorded sounds may be used for predicting problems in the surrounding organs of the heart for better understanding of the medical related problems.

IV. Conclusion

Investigations were carried out with the recorded sounds on the heart corresponding to the three cardinal vowels for four male and female subjects. The analysis of the results showed that the shapes of the signals recorded on female heart are different as compared to that of male subjects. Hence, the results may be useful for medical predictions for better understanding of the medical problems.

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