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Determination of Variations in Heart Sound Caused After Passing through Stethoscope Tube in Two Wired and Wireless Status

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ABSTRACT

The present paper was formulated in order to determine sound passing status from various channels and present a novel method sound transfer considering a few qualitative and quantitative attributes of sound as well as software analysis through wavelet transform. The present paper didn't make use of an independent sound of ECG-type as a reference. Furthermore, unlike previously presented algorithms where heart signal was adopted as a benchmark for healthfulness of the patient, the present work considered pressure difference around heart valves causing high-frequency characteristics in the formed signal. Stethoscope tip was steadily used in all specimens while variables such as presence or lack of tube as well as sound transfer channel to wired and wireless processing system were considered. The tube had a considerable role in sound intensity and frequency resulting in higher auditory quality. The results obtained from the present study can be very efficient in designing new generations of medical stethoscopes.
KEYWORDS: stethoscope, tube, heart sound wireless transfer.

1- INTRODUCTION

Several heart disorders can be diagnosed and determined by use of auditory techniques. Such techniques may come in handy even in some harsh and serious heart diseases as efficient and reliable methods. Nowadays, researchers in several developed and developing countries are creating methods in order to process the heart sounds and also derive their characteristics which are not distinguishable with bare ear. Heart sound is adigital signal which is comprised of two parts which are similar to "Lub" and "Dub".

Since the invention of the first stethoscope by *Laennec*, hearing heart sound has turned to an insuperable part of visiting and diagnosis, especially in heart diseases [1]. Since then, variety of this precious medical tool has been developed. Although numerous applications have been declared for electronic stethoscopes, conventional stethoscopes have not lost their popularity. Despite the fact that conventional models are more inexpensive and easier-to-use, they suffer from some limitation such as difficulty of hearing heart sound precisely in crowded places, possibility of infection transfer, necessity of presence of both physician and patient in a same place, impossibility of hearing heart sound by several people at the same time among others [2,3].

Like other sounds, body organs sounds are characterized by such characteristics as waveform, wave length, frequency, range, intensity, etc. Therefore, the characteristics are interfered and changed by a factor, unwanted variations will occur in the sound. The best way, thus, to hear organs sounds may be a method to increase intensity and volume of the sound without causing any change in other characteristics like wavelength, range, and frequency [4,5,6].

As physicians rely on what they hear in their visits in order to prepare a suitable cure plan,the diagnosed sounds should be evident enough which is not possible without elimination or at least reduction of internal and external noises. Such noises may originate from various resources such as environment, clothes, etc.Another factor possibly causing noises in the sound being heard by physicians is the tool by which sound is heard such as stethoscope tube, wire, or wireless transferor [7,8].

With regard to what mentioned above, the present study was formulated in order to evaluate and compare the changes in heart sound following transfer by wired or wireless stethoscope tube so as to address the effect of each method on heart sound and propose the best method of sound transfer for visiting patients.

2- MATERIALS AND METHODS

2-1- Hardware

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4 stethoscopes *Littman Classic II S.E.* (*3M Health Care, St.Paul, the USA*)were adopted in the present study and prepared for sampling in the following 4 ways: (Diagrams 1-5)

- First) stethoscope tube was removed from its tip and then, microphone was placed in the beginning of sound exit channel in the tip of the stethoscope and connected to a computer using one meter of shield wire.
- Second) stethoscope tube was cut from the end of its direct channel (i.e. where it would make a contact with metal) and then, the microphone was placed inside the tube and connected to a computer using one meter of shield wire.
- Third) stethoscope tube was removed from its tip and then, the microphone was placed in the beginning of sound exit channel and connected to a computer by use of wireless set in a five-meter distance.
- Fourth) stethoscope tube was cut from the end of direct route and then, the microphone was placed in the tube and connected to a computer by use of wireless set in a five-meter distance.

Tubecut in the second and fourth samples was performed by laser cutter with high precision exactly perpendicular on longitudinal axis. The microphone was comprised of a capacitor microphone with a diameter of 75 mm and receiving frequency of 20-120 Hz; therefore, it is capable of receiving total frequency range of a normal heart.

In all above-mentioned ways, the microphone was placed in such a way that its central longitudinal axis was accurately coincided with that of sound route. Then, the microphone was fixed and insulated using PVC silicon glue.

The wire used in all stages was a 2×2 shield wire (*AWM Style, 24AWG*)which has been claimed by the manufacturer to have the least risk of noise. The adopted wireless was an analog wireless *RX/TX FM Audio* (*AUREL, Modigliana, Italy*).

2-2- Clinical status

The present study was performed on a volunteer normal person considering the following criteria: normal heart status, 25 years old, BMI of 22, without history of cardiopulmonary diseases, without any drug use history, not using alcohol and smoke. The heart status of the subject was assessed and confirmed by a heart specialist, then, height and weight as well as BMI of the subject were calculated and documented along with an agreement form signed by the subject.

2-3- Sound recording

Heart sound was recorded in a special acoustic studio for sound recording where the subject sat for 10 minutes in a stable posture to make the heart status stable. Heart sound was recorded by four stethoscopes by one person with the same pressure and placement. Afterwards, heart sound recording was performed in 30 seconds. The recorded sounds were saved in *wav* format.

2-4- Sound processing software

The files were first turned to a suitable format to be processed by the software and then, the recorded sounds processing data were transformed to frequency area by use of *Cool.Edit.Pro.v2.1* Software and binary codes were extracted. Waveform processing was performed by using *TecPlot* Software (version 10).

2-5- Diagram block

The proposed method in the present study was based upon four main stages as follows:

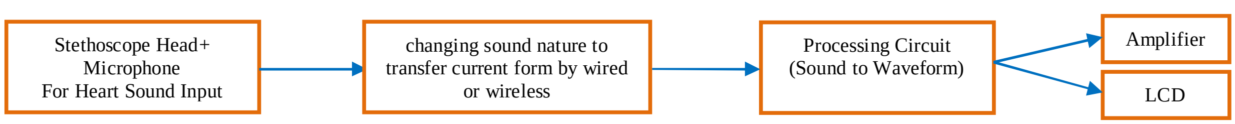

Diagram 1: The basis for designing the methods for the present study

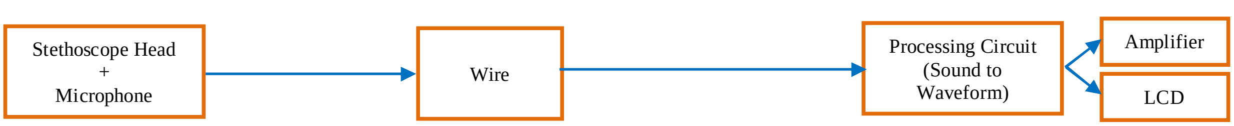

Diagram 2: First method of device preparation

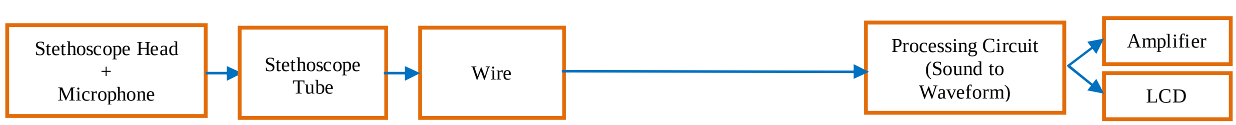

Diagram 3: Second method of device preparation

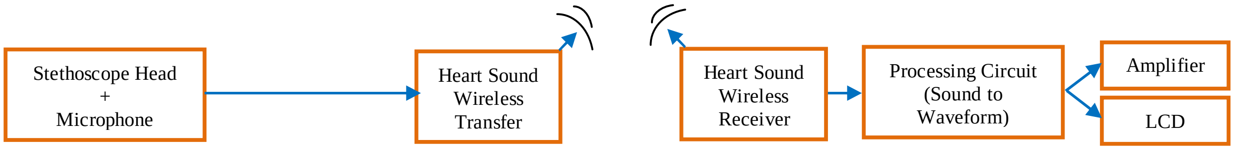

Diagram 4: Third method of device preparation

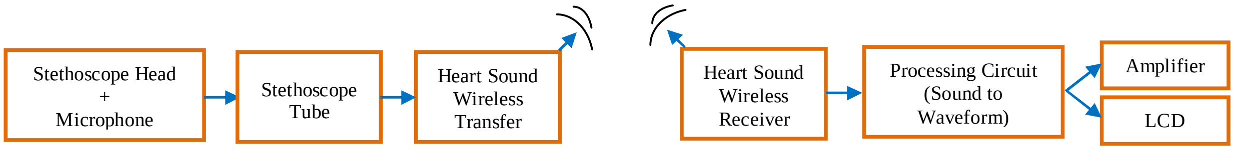

Diagram 5: Forth method of device preparation

3- RESULTS

The results were shown in four status (i.e. A: wired with tube; B: wired without tube; C: wireless with tube; D: wireless without tube) in Table 1.

The results indicate that the processed sounds in the first status had the highest rates of noise reduction and sound intensity.

Table 1: Numerical table of mean processed heart sound

	Wired with tube (A)	**Wired without tube (B)**	**Wireless with tube (C)**	**Wireless without tube (D)**
Frequency (Hz)	11024.99951	11024.99951	11024.99951	11024.99951
Sound intensity (db)	-97.49005574	-96.79345577	-110.4190794	-101.7739625

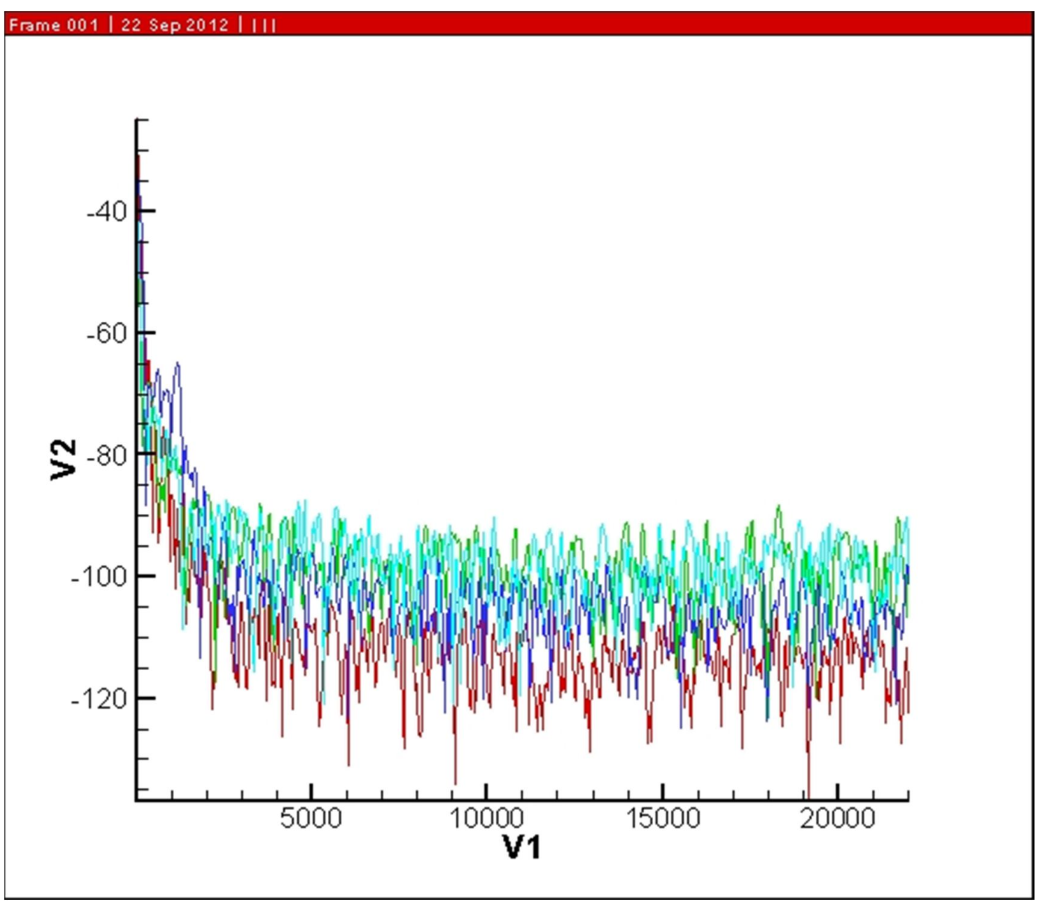

Figure 2: waveform of all analyzed sounds

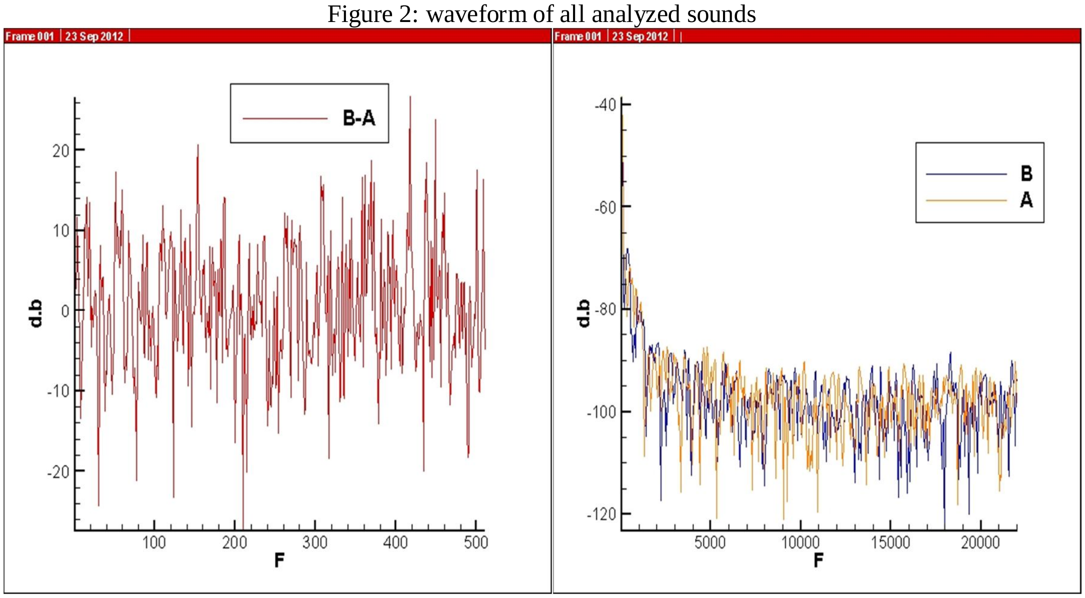

Figure 3: Analysis of heart sound passing through the wired channels with and without tube

As it can be seen above, range is reduced and frequency changed a little in the status B; however, in the status A, range is increased which is an indicative of a better sound quality.

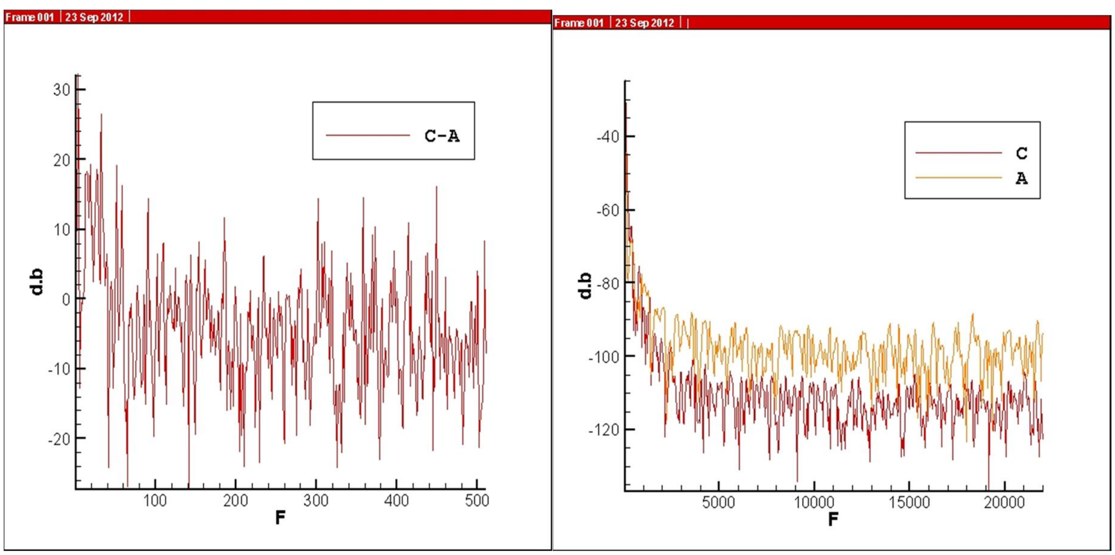

Figure 4: Analysis of heart sound passing through the wired and wireless channels with tube

In the above figure, both cases are with tube; however, one of the cases is wired while the other is wireless. It can be seen that range and frequency experienced more changes in wireless status.

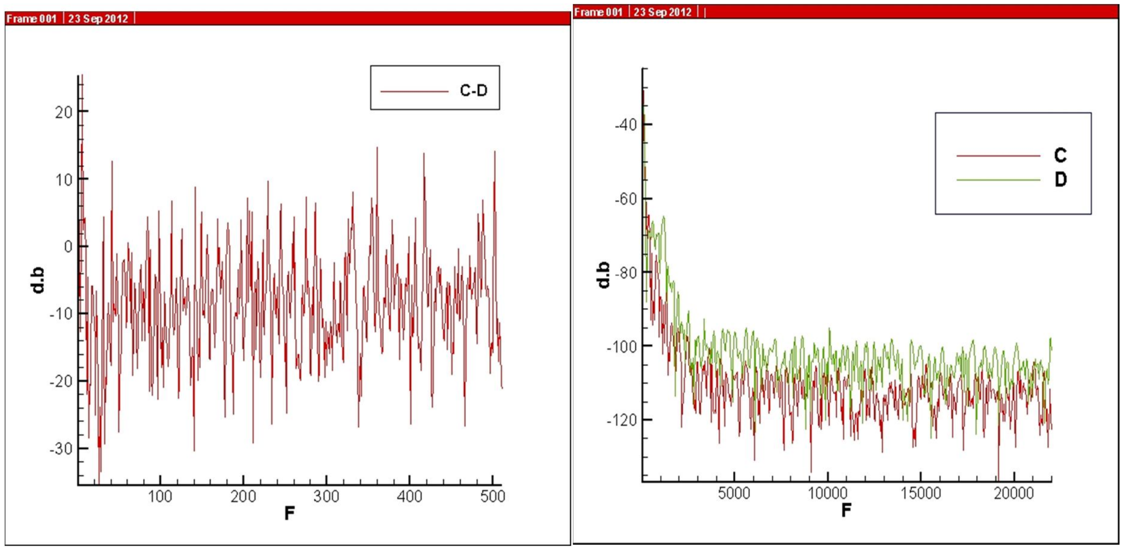

Figure 5: Analysis of heart sound passing through the wireless channels without tube

In the above figure, both cases are wireless; however, one is with tube and the other is without tube. Range reduction and frequency change were more pronounced in the status D (wireless without tube).

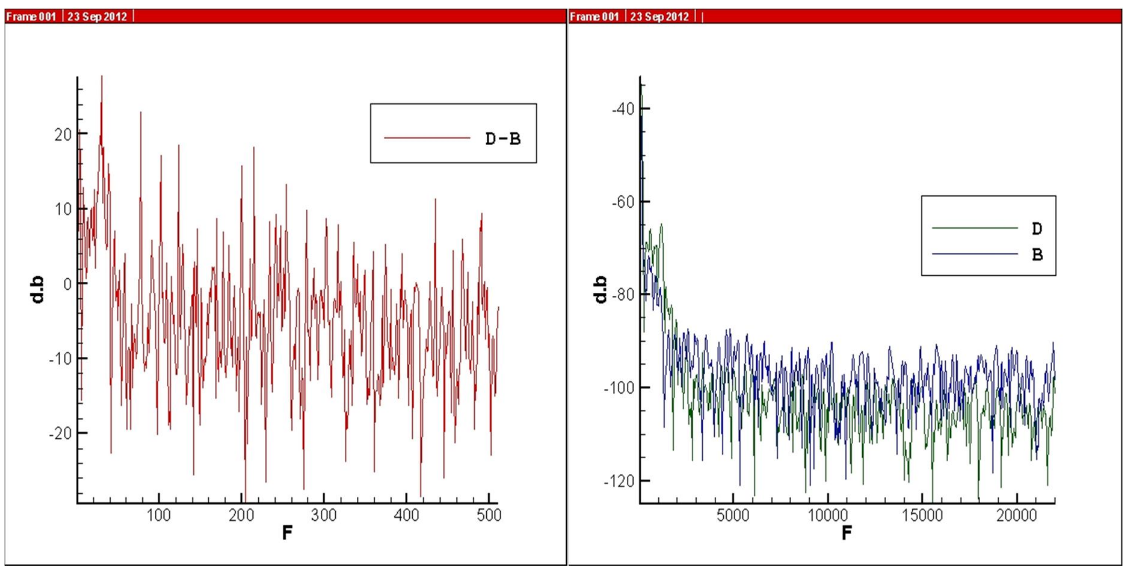

Figure 6: Analysis of heart sound passing through the wired and wireless channels without tube

In the above figure, both cases lacked tube while one was wireless and the other was wired. Range and noise in the wireless case were rather more than those in the wired case.

4- DISCUSSION AND CONCLUSION

Range and noise (intensity and interference) have a mutual relationship in the process of heart sound transfer from a qualitative viewpoint; therefore, the lower noise, the higher sound quality. In addition, as sound range elevates, higher-ranged sounds can be considered to possess higher sound quality, or in other words, sound intensity. Increase in sound range may mean that the sounds with higher range have higher sound quality. Shield-type transferring wires are used due to minimization of noise and voltage reduction.

To the best of our knowledge, no similar studies have been performed before although there were some investigations in this field. For instance, Jiang and Choi (2006) proposed a model for extracting the characteristic waveforms from the cardiac sounds recorded by an electric stethoscope [10]. Myint and Dillard

(2001) proposed an electric stethoscope with diagnosis capability [11]. Sharif et al. (2000) analyzed and classified heart sounds and murmurs based on the instantaneous energy and frequency estimations [12].

Components of a novel wireless digital wireless stethoscope [9] were used in the present study where all factors, except for the analyzed one, were kept fixed. Furthermore, in the present study, recorded heart sound of a volunteer subject was processed and analyzed by use of designed algorithm. The recorded sound evaluation was benchmarked by sound processing experts and qualitatively monitored by a cardiologist. The results showed that wireless exerted a big deal of influence on variations of sound frequencies passing through wireless channel. Furthermore, tube played the role of an amplifier. The tube, in other words, sound transfer channel, has a considerable role to increase auditory quality. The results obtained from the present study may be considered very helpful in designing new generation of efficient wireless medical stethoscopes.

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The authors declare that they have no conflicts of interest in the research.

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