Recommendations Related to Wheeze Sound Data Acquisition

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***Abstract*—In the field of computerized respiratory sounds, a reliable data set with a sufficient number of subjects is required for the development of wheeze detection algorithm or for further analysis. Validated and accurate data is a critical issue in the field of research. In this study, the protocol related to wheeze sound data acquisition is discussed. Previously, most articles focused on wheeze detection or its parametric analysis, but no consideration was given to data acquisition. Second major purpose of this study is to exhibit particulars of our dataset which was attained for future analysis. We compile a database with a sufficient and reliable number of cases with all essential details, in contrast to commercially available wheeze sound data used for research, freely available online data on websites and data used to train medical students for auscultation.**

***Index Terms*—Adventitious Sounds; Electronic Auscultation; Respiratory Sounds; Wheeze Detection; Wheeze Sound.**

I. INTRODUCTION

Stethoscope is a device used for the auscultation of human body sounds. The process of lung auscultation started with the invention of the stethoscope in 1816. With the advent of the computer and its usage in medical, the computerized respiratory sound analysis was started in 1980 [1-3].

Respiratory sounds can be divided into two main categories – normal and abnormal sounds. Abnormal lung sounds stem due to any obstruction in upper or lower airway. Abnormal sounds with information about underlying physiology are known as adventitious sounds and are superimposed on normal sounds [2, 4]. Adventitious sounds can be further divided into two categories – continues and discontinues sounds. Wheeze is continuous sounds with the duration more than 100ms and frequency greater than 100Hz. Wheeze sounds manifest due to obstruction in the lower airway [5]. These sounds are produced in many diseases like COPD, pneumonia, asthma, etc. but most are found in asthma patients [6].

In the field of computerized wheeze sounds analysis, usually, researchers deal with its detection, classification, parametric analysis, and correlation of wheeze sound spectra to lung function values [7]. Wheeze detection is searching a set of peaks meeting wheeze criteria through logic based algorithm [8-11] while wheeze classification is based on learning algorithms [12-17]. The parametric analysis is performed for the understanding of wheeze sounds behavior [4, 18-21]. Computerized wheeze sound analysis is an active field and the number of studies are increasing in this research area [7, 22]. The focus of this study is to describe the steps involved in the respiratory sounds data collection.

The basic element of a developed system or analysis is the selected dataset chosen for experimentation. If the collected data set is not reliable, then results of the investigation cannot be called accurate and reliable. Accurate and validated data can provide reliable essential insight into the problems being studied. It is of paramount importance that defining a protocol of any study is an important issue. In this paper, important recommendations with justifications have been compiled for the acquisition of wheeze sounds. Discussion about particulars of our data, which was obtained for wheeze sound analysis, is also a part of this article.

II. METHODOLOGY

The protocol for respiratory sounds acquisition was designed according to CORSA standards [23] after a detailed study of the literature. The data was collected from asthma patients only, as mostly airway obstruction in these patients stems from one type of adventitious sounds which is wheeze [1, 6]. Hence wheeze sounds related to asthmatic patients is the part of our research.

Steps followed for data collection are shown in Figure 1. The first step is “patient entry” which comprises – name, age and weight, the height of patients. The “history of patient” step involves filling the clinical report form to obtain all details required for asthma diagnosing. In the next step, “clinical examination”, a physician examines the patient. Finally, adult asthmatic patients were taken to the final step “instruction and permission for data collection”. Elaboration on these steps of recordings and all other related details are given as follows.

A. Devices for Data Acquisition

Respiratory sounds can be collected from air coupled microphone or contact sensor (accelerometer). Signal to noise ratio (SNR) for both type of the sensors has been observed same [24]. Condenser microphones, normally attached to the skin through couplers, are known as air couplers [25]. In this study, a wireless digital stethoscope, WISE [26] is used to collect data, which uses the air coupler technique. Few previous studies have also used the same device [27-30]. In WISE, mechanical vibrations are converted into electric signals through an air-coupled condenser. Data has been collected at 8000 Hz sampling frequency which is four times the resonance frequency (2000 Hz) of the device.

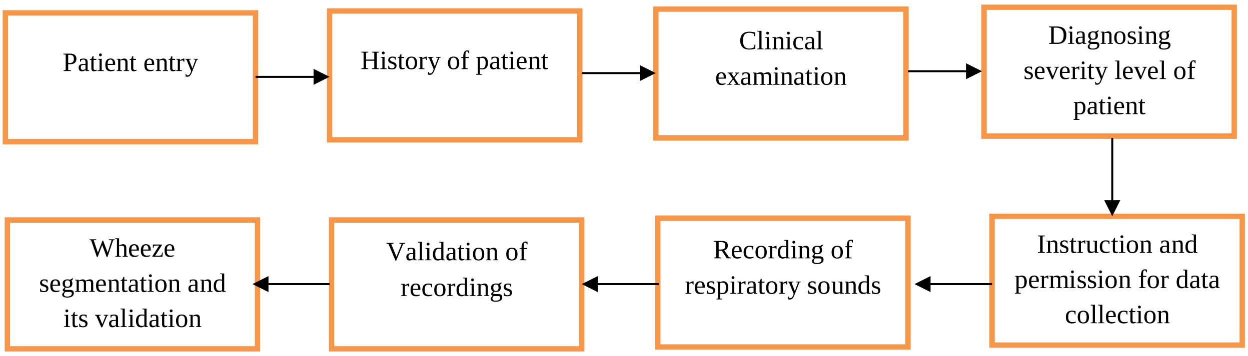

Figure 1: Steps involved in the data collection process

B. *Ethics Statement*

Data has been collected from two hospitals – Al-Mustafa Chest Clinic at Wazirabad, Pakistan and District Headquarters Teaching Hospital at Gujranwala, Pakistan. Ethical permission was taken from the ethical committee of both hospitals separately. Clinical report form was filled by all subjects, and written permission was also taken from subjects for participation in this study. Before the start of data collection, instructions were given to subjects for data collection.

C. *Subjects Inclusion and Exclusion Criteria*

The subjects were recruited on the suggestion of senior medical officers of both hospitals. Selected subjects were non-smokers and are not drug-addicted. Selected subjects were only asthmatic patients, without any other lung, heart or bowl region disease. It was ensured that no medication was taken a few hours prior to data collection, as bronchodilators affect the change in frequencies of respiratory sounds [18]. Subjects with more than one disease (e.g. asthma patient with pneumonia) were not selected. After diagnosing the asthma patient according to available standards [31], severity levels of asthma (mild, moderate and severe) were identified according to [32-34]. Such practices have also been done in other studies [35, 36]. Patients suffering from asthma with mild, moderate and severe conditions were selected for data collection.

D. *Age Group of Subjects*

Another important issue is age group selection for the study. In the literature, most authors deal with adult age group or children [7]. As changes in respiratory physiology cannot be totally ignored within age groups (adults and children) [37, 38], hence it is recommended to collect data from the same age group. All recordings in this study have been done from adults (25-70 year age).

E. *Background Environment*

There are three options to control and reduce background noise. 1) Collect data in a soundproof room with environmental noise < 30 dB [23]. 2) Simultaneous recording from two sensors. One is attached to the human body and the other collect sounds from surroundings. Finally, subtract background noise from lung sounds [39]. 3) Collect data withhold (silent) breathing few seconds before starting the recording and then subtract it from respiratory sounds i.e. subtract the ambient noise. Current data was collected in a soundproof room. Also, environmental and subject's outlook conditions were identical for all patients, hence ambient noise did not vary from patient to patient as described in [40].

F. *Subject's Posture*

There are two types of recordings – short-term and long-term recording. In both types of recordings, respiratory sound properties do not change, the only posture of the subject is different for data collecting. Respiratory sound data can be collected in the supine posture of the body or in sitting position. For long-term recording supine position is recommended while for a short time recording sitting position is recommended [23]. In order to maintain quality and reliability of data, the short-term recording was selected. In the literature, most of the studies have also collected data for a short time [7]. For this study, data has been recorded according to short-term recording for 40 to 70 seconds. All recordings were done in sitting position with hands on the lap. Subjects were asked to breath by way of mouth to exert effects in the upper airway. Subjects were requested to keep quiet and avoid any movement during recording, as a change in position can cause variations in the intensity of wheezes.

G. *Breathing Maneuver*

CORSA standard has suggested two breathing maneuvers for data collection [23] – Tidal breathing and forced expiratory maneuver. Few studies have shown wheeze can also be induced in normal subjects with forced expiratory maneuvers [8, 18, 41] which shows that during forced exhalation wheeze is not related to airway obstruction [42]. Hence, tidal breathing maneuver was selected for data collection.

H. *Data Collection Location*

Respiratory sounds can be collected from mouth, trachea and chest depending on the cause of disease. Data is collected from the mouth for the diseases caused by upper airway obstruction [5]. Wheeze sounds are produced due to obstruction in the lower airway. However, trachea and lower lung base are the positions selected by most of the authors for wheeze data collection [7]. Similarly, the locations are also suggested by CORSA standard [43]. These positions are best for the collection of high frequencies (wheezes) with maximum information about underlying pathologies and conditions of the patients. The exact location for lower lung base was chosen by ordinary auscultation based on sufficient intensity in the sound [44] heard. In our work, based on the literature review and medical officer recommendations, the data was collected from the trachea and the lower lung base.

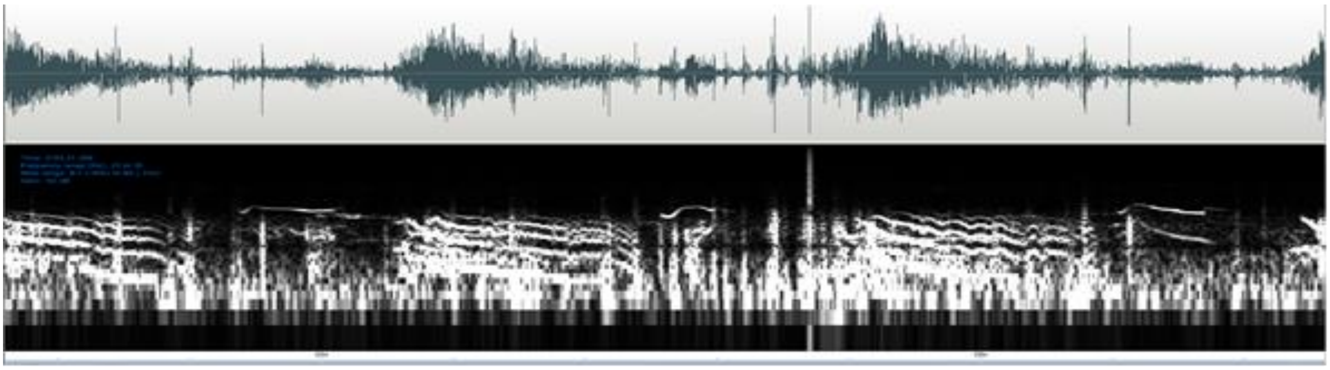

Figure 2: Example of recorded signal

I. Reliability of Recordings

Data reliability is a procedure used to check whether data collected is valid for further analysis, as described in [10]. Reliability of respiratory sounds in the recordings in terms of phases is defined by [36] where respiratory cycles consist of the inspiratory phase, inspiratory pause, expiratory phase, and expiratory pause. During the validation process, sounds with prominent background noise due to heart sounds, talking or bowl noise was rejected. Confirmation and validation of the collected data were done for individual recordings. In our case, each recording was played back and listened to after acquisition, to reconfirm whether it consists of breathing sounds and without any noise.

J. Validity of Segments

In the literature, mostly two types of segmentation have been used – 1) Full breath cycles having adventitious sounds and 2) Continuous adventitious sound segments. For wheeze sound classification, most of the studies conduct learning from wheeze segments [12-17]. Wheeze segments can be further divided into two classes, polyphonic and monophonic, based on its frequency contents. This practice has been held by many previous studies [17, 19, 20, 45].

It is necessary to validate whether the sound segments selected for analysis consists of the adventitious sound part or not. It is also essential to validate if those parts have wheeze related properties such as duration, frequency and its manifestation using a spectrogram.

Only audio inspection of recordings is not enough, as human hearing capacity is limited and it also involves the physician’s experience. Similarly, only visual inspection of the spectrogram is not enough because the representation of spectrograms may also be due some noise like speaking, etc. [7]. In our database wheeze sounds were segmented by audio-visual inspection of recordings with the aid of spectrograms. Selected wheeze segments were validated by a physician.

One of the wheeze segments is shown in Figure 2. In our data set, the severity level of patients was defined by the physician, as practiced in [35, 36]. Similarly, the phases of breath cycles and its associated wheeze (inspiratory and expiratory) was also identified by a physician as mentioned in other studies [12, 17].

III. RESULTS

Till now data has been collected from 55 patients suffering from bronchial asthma and 10 control subjects who were in normal condition. More than 1000 segments have been collected. All the data have been validated and labeled in terms of severity level, location, phase, etc.

IV. CONCLUSIONS

This paper has described a detailed approach on the needs for lung sound acquisition. We have also provided the specifics of our collections database. The collected data in our database has been validated by physicians. In future, further analysis and relevant, intelligent systems will be developed from this data set. Finally, reliability and repeatability of the developed system will be done (using a comparable population and sample size) from various other hospital sites. In the near future, this data will be available online for interactive training of physicians and students.

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