Proceedings of The Institute of Acoustics

THE FREQUENCY ANALYSIS OF BREATH SOUNDS AT THE MOUTH

Miss. M. SCOTT[1], C.J. LEA[2], and G.D. CAIN[2]

[1]MOUNT VERNON HOSPITAL &[2]POLYTECHNIC OF CENTRAL LONDON

Introduction

The sound of breathing at the mouth in healthy subjects has been described as a white noise[1]. The noisy breathing often exhibited by patients suffering from chronic obstructive airways disease produces similar sounds although it has been suggested that there may be a larger proportion of high frequency components present even in the absence of a distinct wheeze. This noisy breathing can be a useful clinical sign but it is often ignored because the mechanism of its production is not fully understood and hence its significance is difficult to appreciate.

Previous work in the field has concentrated on the sounds of respiration as heard over the chest wall which introduces the unknown filtering effect of the intervening tissue. Another disadvantage of this approach is that the frequency response of this recording system is virtually impossible to quantify since it depends upon the pressure with which the microphone is applied to the chest. Sounds recorded in this way are limited to a relatively narrow range of low frequencies with a steep fall in amplitude above 200 Hz.

The work that has been done on breath sounds at the mouth[2] has shown that the intensity of the sounds correlates well with indices of airflow obstruction. From this and other evidence, it is considered that the main source of breath sound production is due to turbulence at the glottis and in the upper airways. Information on the frequency content of breath sounds is sparse. Generally it is held that the frequency distribution of breath sounds at the mouth is essentially flat from about 200 Hz to 2,000 Hz.

This investigation is concerned with the frequency spectrum of breath sounds at the mouth in health and chronic obstructure airways disease before and after bronchodilator therapy with a view to an improvement in understanding the mechanisms of production and perhaps the emergence of a new diagnostic tool.

The problems associated with measuring the breath sounds over the chest were not encountered when examining breath sounds at the mouth although the determination of the frequency response of this recording system is not without difficulties.

Method

The intensity of breath sounds at the mouth is dependent on the flow rate at the mouth so that this parameter is recorded simultaneously with the sounds using the arrangement in Figure 1.

THE FREQUENCY ANALYSIS OF BREATH SOUNDS AT THE MOUTH

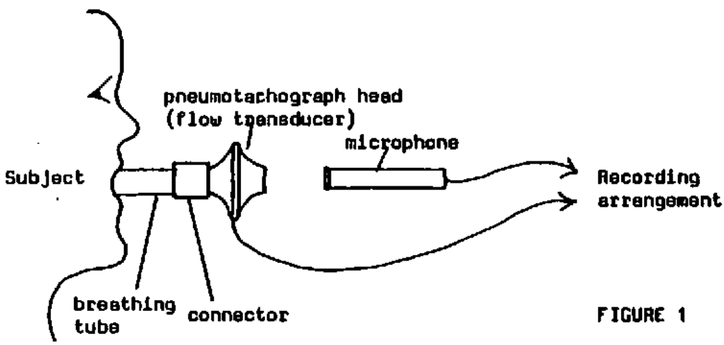

FIGURE 1

The acoustic characteristics of the system were investigated by introducing known signals through a loudspeaker as shown in Figure 2.

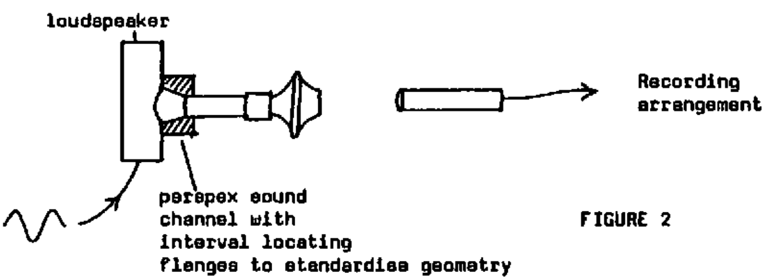

FIGURE 2

It was found that reproducible results could not be obtained on this system. It became apparent that the problem was the plastic connector which was slightly flexible to allow various sizes of cardboard breathing tube to be push-fitted into it. The frequency response of the complete system depended upon how tightly the arrangement was pushed together. This problem was overcome by replacing the plastic connector with a rigid aluminium connector with internal locating flanges for the breathing tube and flow transducer.

It was found that the frequency response of the system exhibited many peaks and these were investigated by determining the response as pieces of the flow measuring equipment were removed sequentially.

One peak in the frequency response was deduced to be a known peak in the loudspeaker response modified by a mechanical resonance of the air contained within the cavity of the breathing tube, connector, flow transducer and perspex sound channel. A further peak appeared to be due to a Helmholtz resonance of this same cavity.

Complete agreement with the theoretical equations for these resonances was not expected nor obtained as the pneumotachograph head incorporates a double wire mesh in its cross-section which enables it to detect flow. This feature will undoubtedly affect the resonant frequencies.

The complete frequency response of the system used to record sounds from patients is slightly different from that used to investigate the measuring system. The differences were examined by comparing breath sounds recorded excluding the flow measuring equipment with those recorded normally but attempting to compensate for the frequency response of the flow measuring equipment.

To obtain the frequency spectra the breath sounds are analysed by a PDP8/E computer. The flow signal is used as a marker to define the timing of the sound sample within the breathing cycle. The computer program used was constructed around a published[3] mixed-radix fast fourier transform subroutine. This ensured a great degree of flexibility in the length of the sound sample to be analysed.

All programs were written or obtained in Fortran except those which sampled the sound and flow on the analogue to digital converter which were written in RALF, an assembler language.

The sampling speed of the analogue to digital converter is limited to 1 sample every 100 microseconds so that the technique has an upper limit of 5000 Hz. A low frequency limit of 100 Hz was set to minimise the contribution of system noise to the signal.

Results

Preliminary results indicate that the frequency spectra of breath sounds of patients suffering from chronic obstructive airways disease show features above 3000 Hz not present in the spectra of normal subjects breathing at the same flow rate.

References

1. P. FORGACS 1978: Bailliere Tindall. Lung Sounds.

2. P. FORGACS, A.R. NATHOO, and H.D. RICHARDSON 1971: Thorax 26, 288-295. Breath Sounds.

3. R.C. SINGLETON 1969: I.E.E.E. Trans. Audio Electroacoust, AU-17, 93-103. An Algorithm for Computing the Mixed Radix Fast Fourier Transform.