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A5_2 Drop The Bass!

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Abstract

In 2004 two newspaper articles claimed that the cause of the spontaneous pneumothorax that a man suffered in his car was due to the 1000 W 'bass box', producing frequencies which caused resonance with the air in his lungs causing them to puncture and collapse. Modelling the alveoli in the lungs as Helmholtz resonators this paper looks to determine if the cause was really due to the frequencies generated by the subwoofer. It was found that the subwoofer could not produce high enough frequencies to achieve resonance with the alveoli.

Introduction

The lungs are made up of around 480 million alveoli [1]. These are air sacs which fill and expand when you breathe in, allowing oxygen to diffuse into the nearby blood vessels. If alveoli are ruptured air can escape into the gap between the lung and the chest causing lung collapse. This is a condition known as pneumothorax [2]. In 2004 an article was published by the BBC [3] which stated that pneumothorax was induced in a man due to the bass frequencies generated by his car's 1000 W 'bass box', a similar article was also released in the Guardian [4]. These articles suggested that the cause of the pneumothorax was due to the air in the lungs resonating with the bass frequencies.

To calculate the resonant frequency of the alveoli we used the equation for a Helmholtz resonator (1).

$$f = \frac{v}{2\pi}\sqrt{\frac{A}{Vl}} \tag{1}$$

Where f is the fundamental frequency, v is the speed of sound in air, A is the cross-sectional area of the opening of the alveoli, V is the volume of the alveoli and l is the length of the respiratory bronchioles.

Assumptions

- The alveoli are modelled as Helmholtz resonator.
- The alveoli can be thought of as mainly air. [5]
- The alveoli in the lungs are homogeneous.
- There is no damping of the sound waves.

Discussion

The radius of the alveoli ranges from 100 - 250 μm [5]. This is due to them filling with air as they expand. As such, the resonant frequency of the alveoli is dependant on the radius as shown by figure 1. The speed of sound used in the alveoli was 340 ms^{-1} since they were modelled as mainly air. The length of the respiratory bronchioles is 0.1 cm and the cross-sectional area of the opening was calculated to be 0.196 mm^2 [6].

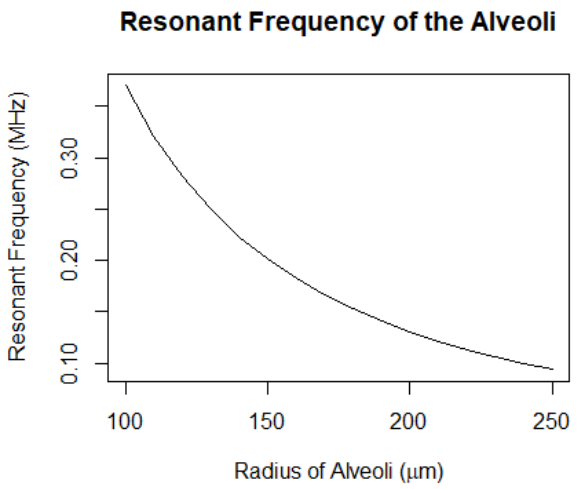

Figure 1: Shows how the resonant frequency changes with the radius of the alveoli. As the alveoli expands the resonant frequency decreases from 0.3701 MHz to a value of 0.0936 MHz.

The resonant frequency of the alveoli was calculated in another paper [7] using a different approach to be 1.834 MHz (this was the maximum value they found) comparing to the maximum value we found of 0.3701 MHz it appears that although our approach was simple it has given values to a similar order of magnitude.

The newspapers state that a 1000 W 'bass box' [3], [4] was in use in the car when the man's lungs collapsed, assuming the 'bass box' is a subwoofer which generally produce frequencies in the range of 20-200 Hz. The frequency range of the subwoofer is too low to cause resonance within the alveoli which have a resonant frequency in the range of MHz.

Conclusion

Since a subwoofer is unable to produce high enough frequencies to cause resonance within the alveoli, we can say that this was not the cause of the spontaneous pneumothorax that occurred as suggested in the newspapers. For future work we suggest modelling the lungs as a whole system as opposed to the individual alveolus to see if and how this would affect our results. We would also suggest creating a model that includes damping.

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