Silicone Head Model with Airway Blockages

Jeremy Galle, Brian Myette, and Madison Moreau, *Biomedical Engineering, University of Rhode Island*
BME 484 Proposal, September 18, 2014 <gallej@my.uri.edu, brian_myette@my.uri.edu, madison_moreau@my.uri.edu>

***Abstract*—Sleep apnea is a debilitating condition for those that have it. A lack of sleep has the potential to drastically decrease a person's quality of life, and therefore a solution must be invested in. The creation of a silicone-based head model with an anatomically correct airway may eventually lead to a permanent solution for those with the condition. By coupling a respiration pump with an electronic stethoscope, we will record frequency data throughout the airway. By creating blockages throughout the airway, we will compare the frequency spectra of a normal airway with a restricted airway. These comparisons will help derive conclusions, which will be used to identify the problematic areas in the airways of people with sleep apnea.**

I. Introduction

SLEEP apnea is characterized by shallow breaths or pauses in breathing during sleep. These pauses in breathing can last between a couple of seconds and minutes; furthermore, they can potentially occur more than thirty times an hour. Pauses in breathing or shallow breaths often move people from a deep sleep into a light sleep, greatly reducing sleep quality. This poor quality of sleep leads to excessiveness drowsiness during the day, which can result in poor productivity at work or school. Furthermore, this could lead to poor driving judgment or generally bad decision-making throughout the day. Untreated sleep apnea can increase the risk of heart attack, stroke, diabetes, obesity, and high blood pressure. Additionally, people with sleep apnea are more prone to heart arrhythmias, and therefore constantly need to pay attention to their health. For these many reasons, a solution must be rigorously invested in. Our project will develop relationships in the frequency spectra between unrestricted and restricted airways; this information can be used to isolate the problematic areas of a restricted airway. Therefore, future device development can focus on specific parts of the airway, opposed to its entirety.

II. Project Management

Our group will consist of a Hardware Engineer, an Acoustic Engineer, and a Project Lead. Madison Moreau, the Hardware Engineer, will construct the silicone-based head model, and will furthermore implement the respiratory pump to properly simulate inhalation and exhalation. Jeremy Galle, the Acoustic Engineer, will devise a system for the easy recording of frequency data on the exterior surface of the silicone-based head model. Finally, Brian Myette, the Project Lead, will have three major responsibilities: he will oversee the team's weekly operations; he will also plan meetings for outside of class; and finally, he will assist both of the engineers in their daily duties. Our timeline spreadsheet is pictured on the third page.

III. Engineering Standards

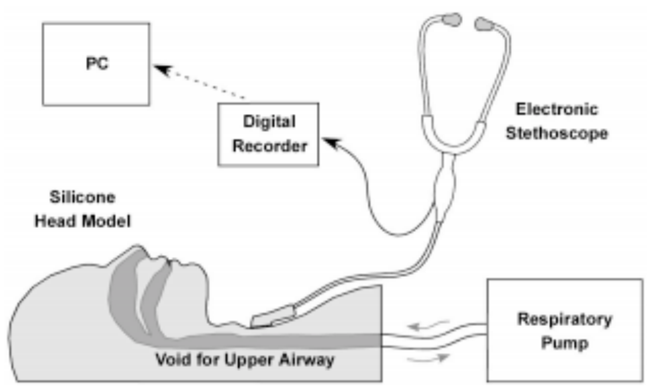
The *AASM Manual for Scoring of Sleep and Related Events standards* says that sleep apnea occurs when three criteria are met. First, there needs to be a drop in the peak thermal sensor excursion by more than or equal to 90% of the baseline. Next, the duration of the event must last for at least ten seconds. Finally, at least 90% of the event's duration must meet the amplitude reduction criteria for sleep apnea. This 90% reduction criterion will prove useful when comparing the restricted airway with the unrestricted airway.

IV. Design Process

To allow ourselves to conduct research on sleep apnea and airway blockages, we must first design a model using silicone. The mold will be of a human head and chest. Inside of the mold, we will have an anatomically correct airway hollowed out from the silicone. To start, the head model will be constructed from silicone that will be poured into an existing mold in a wooden box. The template for the existing mold is a plastic human head and chest model, which is located in the capstone laboratory. After the initial base mold is created, we will construct the airway; this will be accomplished by first carving an anatomically correct airway onto two symmetrical, overlapping pieces of wood. Then, we will fill that mold with gelatin and the borders will be lined with clay. The purpose of the clay is to prevent the gelatin from seeping out of the mold. After the gelatin mold is created, it will be placed inside of a freezer to harden. With the gelatin hardened, we can then place it inside of the silicone mold. To fix the airway so that it is molded into the proper placement, we will anchor the airway to poles on the outside of the silicone box. This will allow the airway to remain fixed while we pour the remaining silicone over the airway. Once all of the silicone is poured into the mold, we will flush the gelatin out by running boiling hot water through the airway. This will allow the gelatin to dissolve, but not harm the silicone head structure. After the airway is clear, we will begin testing its acoustic properties.

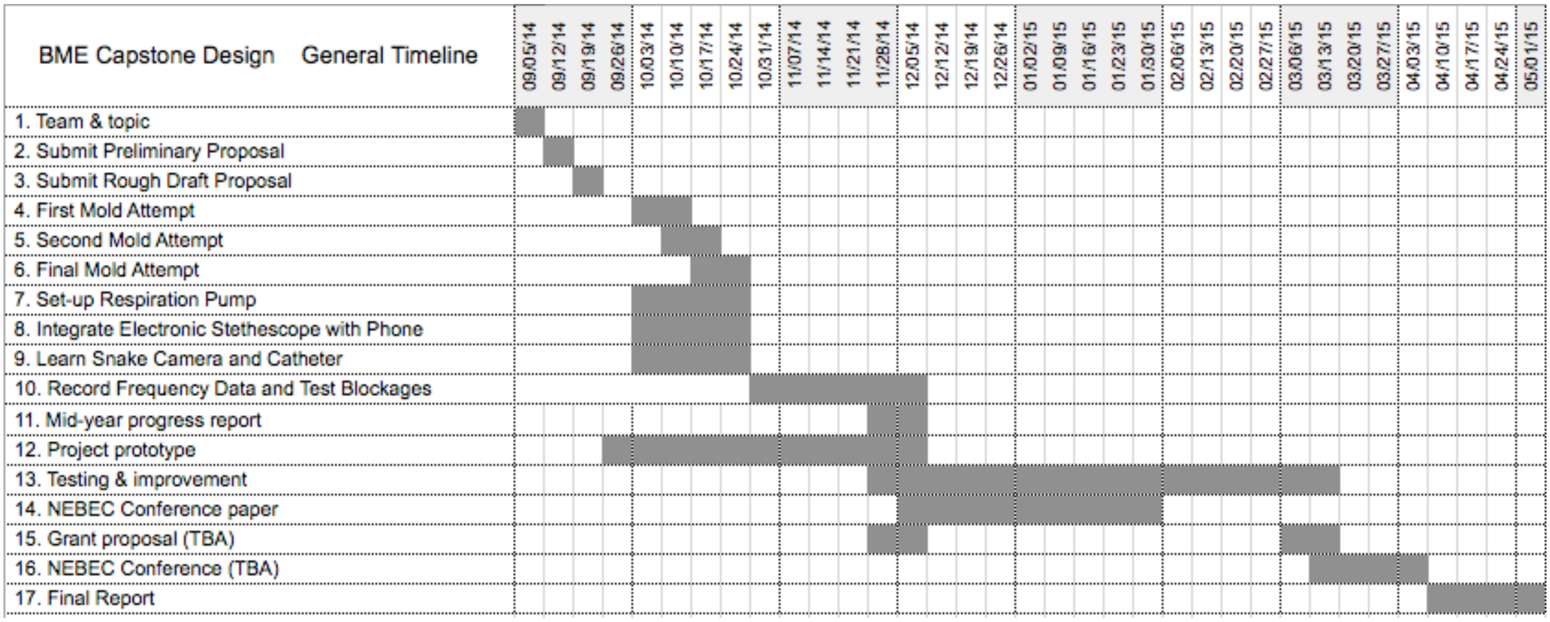
V. Methods

After we have created the silicone-based head model, we will devise a system to measure the frequency spectra throughout the airway, while it is both restricted and unrestricted. To introduce blockages, we will use a catheter with a balloon attached to one end, in order to inflate the balloon to different degrees. In order to introduce blockages in specific areas of the airway, we will use a snake camera with an LED attached to it to guide the balloon to areas such as the nasopharynx or oropharynx. To simulate inhalation and exhalation, we will use a Harvard Apparatus Model 607 respiration pump; this pump's output hose will be stuck directly inside of the hole at the bottom of our head model. In order to record the frequency spectra throughout the airway, we will interface an electronic stethoscope with a frequency measurement phone application via an auxiliary jack. Finally, we will compile the frequency measurements obtained from the application to develop relationships between the restricted and unrestricted airways. A picture of our devised setup can be seen below.



REFERENCES

[1] BME 484 Capstone Design <http://www.ele.uri.edu/courses/bme484/>.
[2] "How Is Sleep Apnea Treated?" *NIH*. USA.gov, 10 July 2012. Web. 12 Sept. 2014. <http://www.nhlbi.nih.gov/health/health-topics/topics/sleepapnea/treatment.html>.
[3] "What Is Sleep Apnea?" *NIH*. USA.gov, 12 July 2012. Web. 12 Sept. 2014. <http://www.nhlbi.nih.gov/health/health-topics/topics/sleepapnea/>.


BME Capstone Design General Timeline
09/05/14
09/12/14
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04/24/15
05/01/15
1. Team & topic
2. Submit Preliminary Proposal
3. Submit Rough Draft Proposal
4. First Mold Attempt
5. Second Mold Attempt
6. Final Mold Attempt
7. Set-up Respiration Pump
8. Integrate Electronic Stethescope with Phone
9. Learn Snake Camera and Catheter
10. Record Frequency Data and Test Blockages
11. Mid-year progress report
12. Project prototype
13. Testing & improvement
14. NEBEC Conference paper
15. Grant proposal (TBA)
16. NEBEC Conference (TBA)
17. Final Report