Present Technology

Currently, there aren't many machines to treat sleep apnea, a condition that affects 12-18 million Americans. The most effective one available right now is called the Continuous Positive Airway Pressure machine or CPAP for short. It consists of a mask, the flow generator and a pipe connecting the two parts. It works by shooting a continuous stream of air into your windpipe so you don't stop breathing while you sleep. There are many variations to the CPAP, including the APAP (Automatic Positive Airway Pressure), which automatically sets the pressure that is needed. Another variation is the BiPAP, which stands for Bi-level Positive Airway Pressure. This is only needed for very serious cases where the patient needs assistance in inhaling and exhaling. There are a couple of settings that you can get the CPAP to do, which includes the spontaneous setting which is where it activates when you stop breathing, the timed setting where it goes of at a set time, or you could do both. The CPAP also includes many different features which includes a heated humidifier to reduce the dryness of the air, the ramp feature, where the airflow starts off at a low pressure and gradually gets higher until it finally reaches the prescribed pressure, exhalation pressure relief, which is a feature that reduces the pressure to make exhalation easier, and a flexible chin strap which encourages patients not to breath through their mouths, but is flexible enough so they can if they need to. There are also many disadvantages to the CPAP. You have to sleep with it on every night and it is very uncomfortable. You have to adjust the pressure and you have to turn of the machine and take of the mask before you can get up.

CPAP Machine

History

Sleep Apnea has been a human condition for as long as their existence, although proper recognition was not made until the mid to late 20th century. One of the first written references to sleep apnea can be attributed to William Shakespeare in his play, Henry IV, Part 1, Act 2, Scene 4;

Peto: "Falstaff is fast asleep behind the arris and snorting like a horse."

Prince: "Hark! How hard he fetches breath."(1 Shakespeare, W)

Reference can also be noted in Charles Dickens' classic novel, "Pickwick Papers" in describing an overweight character named Joe, who often snoozed in midday. In fact, the original term used for sleep apnea was "Pickwick Syndrome", coined by Sir William Olster. Since proper diagnosis and recognition was made, the name "apnea" has been used and is derived from the Greek meaning "no breath".

Researchers have found in hindsight, many notable personalities have suffered from sleep apnea, including, Napoleon Bonaparte, Johannes Brahms, Winston Churchill, King Henry VIII as well as both Franklin and Theodore Roosevelt. Sadly, none of these sufferers of this disorder were ever properly diagnosed or treated during their lifetime.

In 1877, W.H. Broadbent published a paper recognizing the condition; however no clear diagnosis or means of treatment was made. In 1890, neuroscientist and toxicologist, Silas Weir Mitchell, MD also described the condition of sleep apnea and undertook studying this mysterious condition. Unfortunately, this disorder was put on the back burner in light of new discoveries and treatments pertaining to bacteria and microbes.

1 (Shakespeare's Complete Works, pg. 471, Collier & Sons Company, 1925, NY)

It was not until nearly 100 years later, in1965, when French physician, Dr. Gastault made the observation that “Pickwickian” patients had disturbances for the duration of sleep and began to find resolutions. (2, Todman, D.) It was initially thought this syndrome may be due to carbon monoxide poisoning. From that observation, in 1969, Dr. Kuhlo began to identify patients suffering from sleep apnea with the benefits of tracheostomies. This procedure consists of a surgical opening made in the trachea. A plastic tube is then inserted in it to keep it open allowing patients with sleep apnea breathe easier, bypassing the obstructed part of the throat. The tracheostomy hole is plugged during the day so you may breathe and speak normally; otherwise too much air would go into the trachea making speaking difficult.

The first known successful tracheostomy performed for sleep apnea was in 1970 by Dr. Elio Lugaresi at the University of Bologna in Italy. This method was used as the only treatment for sever sleep apnea until 1981.

Some strides were made in the mid 20th century when the use of electronic sleep studies became a reality. This technique was called a polysomnography

A polysomnography is an overnight study in a sleep laboratory. Small electrodes are attached to different parts of your body to measure and record brain waves, heart beat, muscles, blood pressure and oxygen.

2. (Todman, D. /The Internet Journal of Neurology ™
ISSN: 1531-295X A History Of Sleep Medicine)

In light of polysomnographs, by 1976, sleep apnea became easily diagnosed. Stanford University Sleep Diagnosis Clinic, under the direction of Dr. Charles Dement and Dr. Christian Guilleminoult conducted an intense research and study, resulting in a comprehensive report for diagnosing and treating sleep apnea. (3, Stradling)

Spring boarding from Stanford's report, Professor Colin Sullivan first developed the "Continuous Positive Airway Pressure" (CPAP) system at Royal Prince Alfred Hospital in Sydney, Australia in 1981. The CPAP machine blows air at an adjustable amount which is determined after review of polysomnographs in a sleep laboratory. This has had much success in preventing apnea episodes. Ultimately, this method has replaced the radical procedure of tracheostomies. Modified and improved CPAP systems are still in use today.

3. (Stradling, John R. M.D./*American Journal of Respiratory and Critical Care Medicine* Vol 170. pp. 1143-1144, (2004) American Thoracic Society)

Future Technology

Our invention is the SASS (Sleep Apnea Shock System) it consists of an RFID tag that is put in place on the neck of the person with sleep apnea and held in place by a biosteel bandage. Nanowires run from the RFID tag to the back of the head (and into the persons brain; the nanowires are put there by a simple operation.) And when you stop breathing the nanowires send a small shock to your medulla oblongata, the part of the brain that controls your breathing, to make you start breathing again.

3. (Stradling, John R. M.D./*American Journal of Respiratory and Critical Care Medicine* Vol 170. pp. 1143-1144, (2004) American Thoracic Society) Vol 170. pp. 1143-1144, (2004) American Thoracic Society

The nanowires shock the medulla oblongata by the orders of the RFID, the tag tells the nanowires when to shock the brain. The RFID tag is a microchip that is combined with an antenna in a compact package. The packaging of the RFID tag is structured to allow the RFID tag to be attached to an object and be tracked. An RFID is made up of three parts; a scanning antenna, a transceiver with a decoder (which is used to interpret data), and a transponder (which is the RFID tag), the transponder is programmed with information. The scanning antenna puts out radio-frequency (RF) signals, at a short range, and the RF signals do two things. One; they provide communication with the RFID tag and two; they provide the RFID tag with the energy to communicate. The antenna also picks up signals from an RFID reader (a device used to interrogate an RFID tag) and then returns the signal, usually with extra information. This RFID tag is a Passive tag, which is an RFID tag that does not require batteries. They have an unlimited life span. The RFID tag used in SASS is placed on the outside of the skin on the neck of the person with sleep apnea and it is encased in a special casing that will not irritate the persons skin.

The tag is put above the skin because if the tag was put underneath the skin there is a risk that the RFID tag will move around under the skin. The tag is held in place by a biosteel bandage which is a high-strength based fiber material made of the recombinant spider silk-like protein extracted from the milk of genetically modified goats. And the biosteel bandage dissolves slighty into the skin (because of the material its made of), like becoming a new patch of skin, but it still holds the RFID tag in place.

The nanowires that are connected to the RFID tag and the persons skin and when the RFID tag senses that the person has stopped breathing (using its antenna) it tells the

nanowires to send a shock to the brain, the shock will tell the person to start breathing again. The nanowires work like this:

The nanowires are extremely small, billionths of a meter, so they are easily attached to the persons medulla oblongata. And when the RFID senses that the person has stopped breathing it tells the nanowires to shock the person (instead of sending information to a computer.) The nanowires are able to shock the persons medulla oblongata because before the nanowires are put in place, small amounts of electricity are stored in the wires. And when the nanowires are told to shock the person then they will release a small amount of electricity; telling the person to breath again.

Breakthroughs

Identified breakthroughs would be critical to the success of this product. Studies have demonstrated that biosteel is compatible with human skin and would essentially bond and become one with skin as the material is composed of a spider-like protein which is biocompatible. Biosteel, a product made by Nexia Biotechnologies, is developed by using transgenic goats, goats which have been genetically altered to produce a silk-like protein milk recombinant. This protein milk is based on the naturally occurring spider silk, also known as gossamer, which is a protein fiber material spun by spiders.

Biosteel is known for its strength, flexibility, lightness, and toughness. The biosteel would serve as a patch. However, within the biosteel, the RFID tag, or radio frequency identification tag would be made of polymer. The polymer would also need to be biocompatible so as to not irritate the skin. Current RFID tags use polymers or silicon

which could pose a problem. Exploration and identification of a compatible biopolymer would be critical. RFID tags as stated use radio frequency waves. These waves would identify when the soft issue muscles are relaxing and thereby restricting the air flow in the upper airway. Radio waves would need to be evaluated as to their effectiveness and safety when use for this purpose.

The RFID tag would use nanowires for the circuitry. Silicon nanowires are constructed from silicon atoms on silver, these atoms will self-assemble into nanowires. Research indicates that these wires could connect tiny components forming exceptionally small circuits. This capability would be highly beneficial in this patch design. As the radio frequency identification tag identifies the soft tissue relaxing, a message would need to be sent to the brain cortex to stimulate the breathing process. By the application of nanorobots this message may be achieved. At this time, nanorobotics is only a hypothetical proposal. The nanorobots would be formed at or around the microscopic level of a nanometer. For this product, nanorobots would be released from the patch as the identification tag sends the signal. The nanorobots would need to have elements which would provide for accuracy so that the nanorobots would be directed to the brain cortex. These nanorobots would contain molecules which would release charged ions and be capable of providing the message from the brain to the area where the soft tissue is relaxing. With this successfully occurring then breathing would resume.

Design Process

Our team was very excited when we first learned about the ExploraVision project. Our coach told us that we had to create an invention that would be created in the next 20

years. 8 students were chosen for this contest, based on a future technology essay we wrote. Then, the students were split into 2 groups of 4. At first, many ideas came to us.

One idea we had was a way to clone food to stop world hunger. It would've had to be some sort of crop, maybe crops that are high are high in nutrients and is very durable. This would be important for poor counties where people are starving, such as countries in Africa or Asia. This invention would have helped many people in many ways. Though, we felt that sleep apnea would help more people worldwide.

Another idea was a productive way to cure addictions, such as smoking, drugs, or alcohol. Addiction is a large problem worldwide. Current treatments, such as patches or chewing gum are available, but are not very effective. Nicotine addiction is less serious than drugs or alcoholism, but still is very dangerous. It poses threats such as lung cancer or emphysema. Drugs have effects such as brain cell damage and possibly death. Alcoholics affect everyone around them, and from a medical perspective, can cause brain damage and damage to the liver. By curing smoking, many families would be much happier, and this product would be very useful. We could have used carbon nanotubes to find a cure. They could be used in a pill possibly, or another device to control addiction.

Our third alternative idea was a fairly obvious idea recently, finding a cure for cancer using nanotechnology. Cancer is a huge problem worldwide and there needs to be an effective cure. Current cures use chemotherapy and radiation. This treatments kill white blood cells and extremely weaken your immune system. Certain cancers, such as lung cancer or pancreatic cancer, usually result in death. Finding an alternative cure is obviously needed. Using nanotechnology, we feel this is possible. A lot is possible when

nanotechnology is applied. We could make a pill or possibly a patch that could treat the tumor more safely, and it would be much easier.

When looking through our list of topics, we made a fairly quick decision on our topic. We narrowed down to list to about 5, and then decided that finding a better cure for sleep apnea was the best choice. All of the topics on our list were possible, so the choice was fairly difficult. Since making our decision, our group has worked very hard to finish our project, and make it with pride and enjoy every step of the way.

Consequences

As with any new product made using new technologies, there are both negative and positive consequences to be evaluated. For example, it is not yet known if RFID tags could irritate your skin, even when safely covered by a product like BioSteel. Skin irritation or serious adverse reaction may occur. In reference to nanowires, the possibility of a malfunction creating a potentially serious reaction is a concern. Additionally, if the wires were to emit a lower shock than required, the tissue would not jumpstart leaving the soft tissue relaxed. If a shock is administered with greater strength than required, the patient could awaken abruptly or there could be possible nerve damage. Another possible consequence in regard to BioSteel is the potential capability of theft of information by a hacker who could track your movements and gather personal information. This is highly unlikely, yet as with any other tracking device, the possibility would need to be explored.

Cost could be another consideration for this product. Depending on the material used, the product could be costly and components could be expensive to manufacture. People may not desire to have such a device implanted into their brain or other part of their body for the patch. Any permanent change to the human body has both aesthetic and

biological considerations. Radio waves may also cause concerns as they may be affected by other stimuli. For example, cell phones can interfere with hospital machines and are therefore not allowed in restricted area. The RFID tags due to the radio frequency waves may be an issue, both for the user as well as those machines they may be near. The RFID tag may not function if other equipment interferes with its signal.

There is also the issue of surgery. In order for this product to work, the patient would need to undergo a procedure where a magnetized receptor would be implanted. This magnetized implant could cause concerns both as a surgical procedure with the standard concerns and as a possible rejection of the implant itself. Again, cost would be a factor as surgery is not an inexpensive component.

For this product, there would also be concern regarding the safety and ethical concerns regarding nanotechnology. There is the argument that humans should not be genetically altering materials as one would be when using the BioSteel. There is the additional concern that there remain many questions regarding the safe use of nanotechnology whether it is through the use of nanowires or nanorobots. The technology is still new and long term trials have not yet been capable of demonstrating the safety of these scientific advances.

Every product has negative components to consider, however the positive components outweigh the negative ones. For example, most sleep apnea patients do not enjoy using the CPAP machine or any other current treatment. They are cumbersome, difficult to use, or require being connected to a machine while sleeping. With the SASS, people will have the bandage applied and not have to worry about a nightly procedure to follow. Demonstrations have shown that sleep apnea has been linked to such serious

health concerns such as hypertension and heart failure. Undoubtedly, the use of this patch would be very beneficial to patients suffering these and other complications due to sleep apnea. The SASS (Sleep Apnea Shock System) could provide sleep apnea patients with a restful night of sleep, critical to one's health, while relieving the fears associated with suffering from this sleep disorder.