Caring for and Extracting Data from Rats with High-Thoracic Spinal Cord Injuries

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NAME: Misael Rodriguez

PARENTS’ NAMES: Oscar Rodriguez and Maira Sanchez

HOMETOWN: Brownsburg, IN

CAREER OBJECTIVE: I want to become a Project Manager for a tech company or work as an Industrial Engineer in a plant/distribution center.

BIOGRAPHY: I was an undergraduate student at Purdue University and graduated with a degree in Industrial Engineering in December 2022. Initially I was involved in a four-year curriculum at my high school called Project Lead the Way (PLTW) which allowed high school students to work closely with Autodesk Inventor and learn about the design process and aspects of engineering/problem-solving. Through that program I was introduced to the Brownsburg Robotics Team where I was a part of the graphics and finance team, which participated in FIRST robotics competitions. It exposed a lot of high schoolers to the design process, programming, coding, finance and lots of other aspects of engineering when trying to build their robot from scratch. All these things ultimately lead me to pursue engineering in college. Being a part of the Rising Scholars Program allowed me to participate in the Purdue Minority Engineering Programs’ (MEP) Academic Bootcamp. There I was able to experience a semester of Purdue’s first year engineering (FYE) curriculum in a summer and determine I wanted to go into Industrial Engineering. While at Purdue, I was involved in the National Society of Black Engineer (NSBE) and the Latinos in Engineering and Science (MAES). In MAES, I was able to hold leadership positions and be the secretary and treasurer. I was also very involved in the Purdue Bands & Orchestra organizations and played the clarinet in the Purdue All-American Marching Band, Wind Ensemble, and Boiler Brass. Throughout my time at Purdue, I interned as a Field Industrial Engineer for Lowe’s and a Project Manager for Cisco System. Now post-graduation I work as an Industrial Engineer for Lockheed Martin.

FACULTY LSAMP SPONSOR: Dr. Bradley Duerstock, Joint Professor of Biomedical and Industrial Engineering

LSAMP GRADUATE STUDENT NAME: Shruthi Suresh

GOAL OF THE WORK: The goal of this research was to collect data from rodents and see how their bodies before having a high thoracic spinal cord injury and collect data after using ECG equipment. This data was collected to eventually develop a watch that notifies when individuals with high thoracic spinal cord injuries are experiencing the medical emergency of autonomic dysreflexia.

PERSONAL STATEMENT ABOUT THE LESSONS LEARNED FROM THIS EXPERIENCE: With this experience I was able to learn a lot about the medical side of engineering and how a biomedical engineer works in research settings and how individuals with high-thoracic spinal cord injuries function and live. Since I worked a lot with lab rats, I was able to learn a lot about the anatomy of rats and how ECG tests are set up and analyzed and how to be able to translate that process and data to humans. I also learned important time management skills and sticking to a schedule since I was a part of the LSAMP program and needed to provide updates to Dr. Duerstock and Shruthi. At the time, I had only completed one year of first year engineering and had no experience prior so everything I was exposed to was a learning experience. Thankfully I was able to apply a lot of those skills I learned to future internships and project later on in my college career.
Caring for and Extracting Data from Rats with High-Thoracic Spinal Cord Injuries

By Misael Rodriguez

Abstract

Individuals who suffer from spinal cord injuries are very susceptible to autonomic dysreflexia, which unfortunately can lead to death in many cases. By studying this injury, a better understanding of the topic can be achieved, along with potential direction for assistive technologies. The purpose of this study was to ensure that rats with High-Thoracic Spinal Cord Injury were being properly cared for throughout the experimental acclimation process, with proper housing, surgical procedures, diet, and post-operative care. In the lab, these objectives were met, and then blood pressure and electrocardiography recordings were taken before and after the animal was paralyzed. This data was then analyzed with baseline and startle recordings to see the changes that these animals go through after a high-thoracic spinal cord injury. The technology developed from this data could help prevent autonomic dysreflexia and help those who suffer from spinal cord injuries have an easier and more tolerable lifestyle.

Keywords

Animal Care; Animal Wellbeing; Autonomic Dysreflexia; High-Thoracic Spinal Cord Injury; Training Procedures; Rats

Introduction

This paper summarizes the details of the author’s experiences during a faculty-directed research program through a Louis Stokes Alliance for Minority Participation (LSAMP) project under the supervision of Dr. Bradley Duerstock of Biomedical Engineering to produce a guide for the care and acclimatization of experimental rats. Autonomic dysreflexia is a potentially dangerous, and in rare cases, a lethal clinical syndrome that develops in individuals with spinal cord injury, resulting in acute, uncontrolled hypertension (Stephenson, 2022). This causes an imbalanced reflex sympathetic discharge. Individuals who suffer from spinal cord injuries are very susceptible to autonomic dysreflexia and need assistive technology to have a more comfortable and safer lifestyle. Since this syndrome is so rare and abnormal for those with high thoracic spinal cord injuries, it has been neglected, and there is little to no technology available to help assist this specific group of individuals. To experience
this syndrome, the individual usually has damage above the T6 level on their spine (Allen & Leslie, 2022). Unfortunately, 90% of patients with higher level injuries of this kind are susceptible to contracting it, which is a serious issue, due to the complexity of the syndrome (Allen & Leslie, 2022). For those afflicted with autonomic dysreflexia, it can occur up to 40 times per day which is very concerning. Dr. Bradley Duerstock, the professor in charge of the biomedical engineering lab doing this research, works hard to help these individuals struggling in their day-to-day life and has accomplished much in the area previously. He has won multiple awards while at Purdue University and the National Science Foundation. Additionally, he has had multiple PhD students win first place or become finalist in various engineering research competitions. Dr. Duerstock strongly believes that continuous research in human factors is the way to make technology more accessible to individuals, and he was the overall supervisor of this effort. Creating assistive technology to combat this is important because of how this rare medical emergency can become deadly in a short amount of time.

**Experimental Design**

For the blood pressure acclimation, the rats are allowed to grow accustomed to a holding device, which immobilizes the animals for the experimental procedure. This is done by placing them in the holding device for ten minutes on the first day and then fifteen minutes on the second. Before placing the rats in the device, they are also acclimated to peanut butter. The rats were conditioned using peanut butter as a calming method to allow the collection of the most accurate data. After the rat was calm and relaxed in the holding device, then the process of acclimation for blood testing was conducted. The instruments used to record the data were placed on the rat’s tail, and the first acclimation trial was done for ten minutes, which lasted for fifteen cycles with one second in between each one. After that, a second trial was performed for fifteen minutes, which lasted twenty-five cycles with one second in between each one. Once this task was performed, the rat was considered to be successfully acclimated to the device, and the research team would be able to properly record data from the animal. Another important thing to acclimate the rat to was the electrocardiogram device. There was a baseline recording that had no sound, and a startle/agitation recording that had ten seconds of white noise. Initially, there was a ten-minute trial tracking for the blood pressure and ECG together for both the baseline and startle. Then, a fifteen-minute trial tracking for the blood pressure and ECG was conducted again, with the baseline and startle noises.

Post-Surgical Care is very important for recovery and quality of life for the animals. Both the surgery and the recovery are very intense and traumatic for the animal (Ramsey, et al., 2010). Grip pads are provided in the cages for stability and easy movement. Food pellets are placed on the ground for easy access. The food was also crushed and mixed with water to help the rats with spinal cord injury eat more easily. There was also a hideout within the cage for the rats to allow them to stay hidden and relaxed. Buprenex, a painkiller, was subcutaneously
injected and given twice a day according to the animal’s weight. Ketoprofen, an anti-inflammatory medication, was likewise given once a day, also according to the animal’s weight. Bladder expression was done three times a day to ensure that a urinary tract infection did not take place and cause the rat to die prematurely. The balance of this paper will present blood pressure results for the animals, showing images for one cycle and fifteen cycles of the ECG results. How the image of ECG was recorded and an explanation all the experimental equipment will be provided. The heart rate, skin nerves, and other factors that could influence the experiment will be discussed.

**Results and Discussion**

In three months, nine rats were acclimated for testing. Three rats were operated on, and two were successfully given spinal cord injuries. Unfortunately, none of the initial rats with spinal cord injuries survived long enough to collect data. Six more rats were then acclimated for blood pressure and ECG recordings to prepare them for surgery under the current program. In the future, baseline and startle blood pressure and ECG recordings will be collected from all rats who are selected to endure spinal cord injuries.

In Figure 1, a blood pressure graph for one rat is displayed during the twelfth cycle out of twenty-five. The red line represents the O-Cuff, which is a circular blood tracking device placed at the base of the tail. This device helps determine the average blood flow leaving the tail. The blue line represents the VPR-Cuff, which is the cone-shaped device that is placed near the tip of the tail. This represents the rise and fall of the blood pressure, while the device compresses and then decompresses on the end of the tail. Examining at the data, it is evident how the O-Cuff line exhibits a steady fall in blood pressure, indicating the blood is flowing regularly, while the VPR-Cuff has a nice rise and fall intersecting the O-Cuff line. This pattern is normal.

In Figure 2, the raw ECG, heart rate, raw skin nerve activity, and the integration of the

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*Figure 1 - Typical blood pressure graph for rats under the approved baseline experimental protocol.*
skin nerve activity are synchronously displayed from top to bottom of the graph. The startle in the middle of the graph is evident. The startle event began at 3.5 seconds and ended at about 5 seconds during this run. The data show how the rat's body reacted to the stress before the surgery. Once the surgery was completed, the same tests would be performed, and the way the body reacted after surgery would be compared to how the specific animal did previously, prior to the spinal cord injury. Figure 3 provides an expanded view of the same data from Figure 2, with the period from 16.2 seconds to 1.0 seconds expanded for closer examination.

This study provided a pre-operative data baseline for all future rat experimental spinal cord surgeries within the lab. Many aspects of acclimation were modified to ensure the
animals were safe. Blood Pressure and ECG tracking were also improved overall to get more accurate results. Lastly, methods for the surgical procedure to paralyze the rats were improved, so that after surgery, the rats were successfully given a high-thoracic spinal cord injury.

**Summary**

Through this experience, multiple practical issues about the anatomy of a rat and how to handle them were explored, as well as how surgical procedures work and the professional etiquette of dealing with vertebrate animals. Performing injections on a rat and learning where to insert various needles was introduced. Training and the complexities of dealing with controlled substances and the importance of documentation when working with these medications was also provided. Surgeries on rats will continue to be performed by Dr. Bradley Duerstock and Shruthi Suresh until substantial data is collected from these high-thoracic spinal cord injury experiments. A weakness in the current process is the technology being used to record the data from the rats. It was very outdated and could be easily upgraded to more modern instrumentation. An advancement in the equipment could help with the accuracy of the data, and it would reduce the time it takes to record the data from each rat. Additionally, the location of where the work takes place is very small and in need of revision. Possibly renovating the lab or moving it to a larger location and updating its features would help a lot with mobility and the quality of the acclimation process, surgeries, and data collection. This research should help others studying the complex concepts of how the body works following the unfortunate event producing a high-thoracic spinal cord injury. This data might help others have some insight into the repeating physiological patterns shown in rats, which can be directly applied to predict what might occur within humans with similar injuries.

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**References**
