

Computational Modeling of Anastomotic Esophageal Stricture Post-Corrective Surgery for
Esophageal Atresia
(Technical Report)

Cultural Perspective on the Integration of Medical Techniques into a Health System
(STS Research Paper)

Presented to the Faculty of the School of Engineering and Applied Science University of
Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree Bachelor of Science,

School of Engineering
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Fall, 2017

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Introduction

During my summer experience working alongside clinicians at the UVA hospital, I gained insight into how patients are diagnosed and treated. While learning about physiological processes from a clinical standpoint, I was able to apply my own biomedical knowledge to ask critical questions. Because of this, I was able to identify areas of need in the hospital, and discover where biomedical engineering could be used to improve a patient's experience. My curiosity for congenital disorders is what led me to my interest in Esophageal Atresia. This, combined with my conversations with parents of pediatric patients being treated for a variety of atresias made me realize how few effective procedures exist to mitigate the complications that arise from this disorder. For my capstone project, my team and I are using various computational models to gain a better understanding of esophageal strictures which arise from the corrective surgery for esophageal atresia. We will work with graduate students from mechanical engineering and their professor, Dr. Haibo Dong, to create 3D models of the esophagus to determine the highest areas of stress.

My STS Thesis will also consider how disease processes are clinically treated, but from a broader, cultural lens. I will be focusing on what is considered a 'medical application,' and how it is integrated into a health system. I will also be addressing what is considered to be a beneficial medical approach in western culture, and how this perspective differs from Chinese medical practices. These questions will be asked in the context of substance dependency, and how it is treated in different corners of the world.

Technical Report

(Research and Review conducted with team members Inusah Diallo and Anant Tewari)

Esophageal atresia is a birth defect that impacts about 2.8 individuals per 10,000 births in the United States. The condition occurs when the esophagus pre-natally develops into two discontinuous portions instead of a single passage-way (Kuo & Urma, 2006). This can result in complications such as the inability to eat food or drink fluids. C-type atresia is the most common form and occurs when the upper portion of the esophagus forms a pouch and the lower section attaches to the trachea. The current treatment method is a corrective surgery that connects the two portions of the esophagus (Scott, 1993). In about 20-50% of patients who receive surgical treatment for atresia, a narrowing of the esophagus, called an anastomotic stricture, can occur post-operation. The large deviation in repeated esophageal stricture results from variations in the etiology, corrective surgery, and patient-specific immune system factors (Fan, Abed, Zhang, Khan, & Smith, 2018), but highlights the frequency of individuals requiring post-surgery adjustments (Raitio, Cresner, Smith, Jones, & Losty, 2016). Currently, there is no definitive cause for the anastomotic strictures and the current treatments are not permanent solutions.

The larger objective of this study is to reduce the frequency of hospitalization readmission for patients experiencing esophageal stricture post-corrective surgery. Readmission typically consists of dilation treatments to expand the stricture site and have recently incorporated additional physiological and mechanical methods. These methods include the placement of either plastic or metallic stents, and the use of topical injections. Determining further novel solutions to dilations will decrease the recurrent visits to hospitals and drastically improve the standard of living for patients experiencing esophageal strictures. Our broad rationale stated allows for a holistic approach in counteracting myofibroblast buildup and

deposition of scar tissue (Simsek, Aldamanhori, Chapple, & MacNeil, 2018). Taking a step back to understand the specific inflammatory mechanisms present within the esophagus and conducting extensive computational and imaging analysis on the esophageal stricture site will shed light on what complications can arise from an *in vivo* treatment.

The current market defines overall generic solutions applied to all patients, which have significant complications and consequences after administration, including retrosternal pain, bleeding, and recurrent inflammation (Lange, Sold, Kähler, Wessel, & Kubiak, 2018). Mechanical modeling through a computational approach will highlight areas of high stress in the esophagus and flow parameters that are specific to the images of each patient. This will provide a clear understanding of what is happening to esophageal tissue and the cellular activities in specific patients, allowing for clear and unique solution to improve readmission rates.

A novel solution for anastomotic strictures would contribute significantly to scientific fields. Stricture is a common complication arising in smooth muscle tissues, including the colon and urethra. Current research seems to indicate that strictures are a result of scar tissue build up in the esophagus after corrective surgery for atresia (Jansen et al., 2004). If a treatment is created then similar conditions caused by scar tissue build up can be improved upon, including post-heart attack cardiac dysfunction, colon stricture, and urethral strictures. Additionally, a new permanent solution would significantly benefit public health as a permanent solution would reduce the amount of time and frequency a patient would have to stay in the hospital. Furthermore, most patients with anastomotic strictures would be children. Research has shown that frequent hospital stays and visits can be detrimental to the cognitive and physical

development of children (Adams, Smith, & Ruffin, 2000). As such, reducing the amount of time these children spend in the hospital would help reduce any disruption to their early development.

STS Thesis

In 2016, every 8.5 minutes, of every hour, of every day, for the entire year, someone in the United States died of a drug overdose (Hedegaard, Bastian, Trinidad, Spencer, & Warner, 2018). This death toll rose 54% from the five years prior, with opioids such as fentanyl proving to be increasingly deadly as each year passed. In fact, the death toll caused by fentanyl and other synthetic opioids continues to grow at a harrowing rate, increasing from 0.3 per 100,000 in 1999 to 9.0 in 2017 (Scholl, 2019). These startling numbers affect an expansive age demographic, with those between the ages 15-45 having the highest prevalence of overdose-related deaths (Scholl, 2019). The concept of addiction is swathed in notions of choice, and habitual, recreational consumption. At least, this is how those not suffering from a substance dependency will describe it. The word “addict” in and of itself is already drenched in negative assumptions, and often says more about the sentiments of the person speaking than to the individual being referred to. The term implies a deep separation between substance dependency and other medical conditions, such as diabetes, or heart disease. For many, the term “addict” manifests a picture of a criminal, and not a patient. It sets up a framework that intentionally segregates an individual from other patients suffering from other chronic disorders. The etiology of addiction does not correlate to current treatments, with a major cause of addiction stemming from genetic and behavioral vulnerability (Tarter, Cochran, & Reynolds, 2018). In fact, in the United States, drug abuse treatment is more readily emphasized in the legal justice system than within the health system. The systems currently in place reflect and augment the sentiments alluded to by national policies.

From the Controlled Substances Act in 1970, to the Anti-Drug Abuse Act of 1986, legislative documentation passed represents a punitive and not rehabilitative stance on substance dependency (“The Controlled Substances Act,” n.d.), (“H.R.5484 - 99th Congress (1985-1986),” 1986). While the clear intention of these policies is to decrease the use of illegal substances as well as decrease related deaths, the methods used do not result in effective progress. For my paper, I will be focusing on medical inadequacies, as opposed to the overemphasis of the legal system. Because of this, I will be exploring how physiological (internal factors), as well as situational (external factors), are being addressed in the medical treatment of addiction. I hope to answer the questions: “in what ways are different medical applications integrated into a single health system, and what is the reasoning behind this?” and “how is this relevant in the context of addiction across different cultures?”

Literature Review

Before investigating these questions, I want to understand the roots of medical practice in North America. It will be of importance to understand the rise of philosophies such as cartesian dualism and mechanicism, which will help shed light onto the reasoning for current medical practices (Martins, 2018). These concepts refer to the body and mind as separate entities, and state that a sickness manifests as a disruption of the body's homeostatic mechanisms. This disturbance is treated as a mechanical issue that can be fixed through the application of medical knowledge. Under these assumptions, the mind does not abide to mechanical laws. From preliminary research, it seems that current North American health systems attend to illnesses that abide by mechanical law, and that this reasoning is also used in the context of addiction. Parallel

to the mind/body split, it is also important to understand the mechanisms of pain, and the rise of pain management. While having measurable consequences, pain itself is subjective and varies not only between individuals, but also between cultures. It has also been noted by such readings as *The Spirit Catches You and You Fall Down* by Anne Fadiman that a patient's pain will have varying responses from medical providers depending on the cultural bias present, and a providers ability to understand/empathize with a patient's needs (Fadiman, 1997). This comes with understanding the social norms of cultures not native to one's own way of life, with one example being the appropriateness of the discussion of death to patients and their families (Givler & Maani-Fogelman, 2019). While some cultures see this as a necessary topic to discuss with clinicians, many cultures also see it as taboo, and correlate these conversations with an increase in likelihood that an ill-fate will befall a loved one. Because of this, it is important to compare practices within North America to a country that has a different viewpoint on medical practices. The treatments prescribed for substance dependency can be used to highlight the values ingrained in medical practices of different cultures.

STS Framework

This research will be carried out by examining the social construction of target populations, specifically those experiencing a substance dependency (Schneider & Ingram, 1993). This framework will be used to determine why this specific population is treated with certain medical applications, and why this illness carries a certain connotation. It will also be used to address how social stigmas influence people of power, and how these assumptions translate into laws and policy. The reaction of the target population to these laws and policies

will also clarify how this population feels it is being treated. The main motivation behind using this framework comes from the investigative research behind it. It seeks to ask the whys, such as why different medical applications are integrated into a single health system, why these applications are used to treat addictions, and also, why these applications differ across cultures.

Methodology

While substance dependency is universal, the range of treatments for it is not. One key aspect of this STS 4500 course is that is also being taught at Tsinghua University in Shenzhen, within the Chinese province of Guangdong. Because of this, we are able to engage with students learning similar topics from a different cultural background. At an institution such as the University of Virginia, it is common to become dialed in on a specific routine, and with that, a specific way of life. It's not surprising that enrolling in a course along with students from a different country has a way of making students think critically about other cultures and countries. Speaking with students at Tsinghua University about topics discussed in class adds dimension to the concepts we are learning. While the same information is taught, student discussion between classrooms is widely variable. Interviewing students at Tsinghua will be vital for my research, as we can converse about differences in medical practice and the effectiveness of these practices. The cultural values learned from these discussions will help to frame and contextualize the different medical approaches taken in America versus China.

I will also seek examples of non-western medical practices being used within the City of Charlottesville. From the McCue Training Center for UVA athletes, to private businesses, there are multiple examples of traditional medicines being used in a modern context. Listening to the

thought processes of the medical providers who use these practices will provide examples of how different cultures become integrated into different communities, and the context in which multiple cultures can exist.

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