Computational Modeling of Esophageal Stricture

(Technical Paper)

Understanding the Influence of Healthcare Systems on the spread of Medical Tourism

(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Introduction

In 2011 Kobe Bryant, celebrity and world-renowned basketball player, traveled to Germany for a controversial yet effective knee therapy treatment. He affirms this procedure as a key to his success in the NBA as he ages. The benefits of this treatment and application to a larger than life figure begs the question, why is it not allowed in the United States, and do decisions to travel abroad for medical purposes influence a country's healthcare system?

Medical surgeries, procedures, and treatments within healthcare represent an immense part of a developed nation's economic sector. Each year, new techniques, methods, and ideas are developed to combat injuries and diseases (Jakovljevic & Ogura, 2016). However, the different standards of each country result in questions being asked regarding implementation of new medical policies, leading to heterogenous approval of procedures around the world. The lack of uniformity has led to the notion of medical tourism in which individuals will travel abroad to receive alternative treatment options (Béland & Zarzeczny, 2018). In the current medical and economic climate, many factors play a role in individuals traveling abroad for medical purposes, including: lower cost treatment abroad, regulation of medical procedures by domestic governments, broad influence of healthcare systems, and higher quality of care in foreign countries (Perkumienė, 2019). The goal of this study is to analyze the influence of healthcare systems and national regulations of health practices on medical tourism and determine if medical tourism is truly beneficial in helping individuals receive optimal care.

Esophageal atresia is a known birth defect in infants in which the esophagus is not properly connected to the stomach, resulting in an inability to digest food items. Upon diagnosis, corrective surgery is conducted (Desai & Moustarah, 2019). A common side effect of the corrective surgery is esophageal stricture resulting from the buildup of scar tissue at the site of

repair, causing narrowing of the airway and continued inability to swallow food items. Methods of reducing post-surgery stricture rates in patients is an active area of biomedical research and engineering (Fan & Xiaowen, 2018).

Understanding medical regulations and the healthcare systems within countries is incredibly important when designing long-term medical solutions to be used clinically. Gaining insight into the migration habits of medical patients around the world will allow research advancements to be more patient and region specific, contributing to improved long-term treatments. A greater appreciation for the significance of medical tourism will drastically help the design of a long-term solution to esophageal atresia, a birth-defect found worldwide.

Technical Topic (Capstone)

Presently, pediatric patients that have undergone atresia induced corrective surgery face serious and life-altering complications. The incidence of esophageal stricture post-surgery is relatively high, with as many as 30-40% of cases resulting in complications (Pinheiro et al., 2012). There are currently no clinical metrics used to determine whether a patient's esophagus diameter qualifies as "strictured", because of this, balloon dilatations are based on a patient's symptoms. While the term "esophageal stricture" is not defined by parameters relative to individual patients, "recurrent stricture" is. This is defined as the inability of the esophagus to maintain a satisfactory luminal diameter of 14 mm for more than 4 weeks (Kochman et al., 2005). Some of these symptoms include difficulty swallowing food items, as well as pain in the throat and chest. Because of this, treatment for esophageal stricture is completely reactionary, and is a result of a parent's constant monitoring of their child's feeding habits. We hope to shift the treatment of this congenital defect from reactionary to something more permanent.

Two routes of treatment have been explored in the 21st century: mechanical procedures and therapies, and topical injections (Siersema, 2019). Figure 1 specifies the treatments within each category, and while there seems to be multiple treatment options, the efficacy and permanence of them are questionable. Within injection-based therapies, small studies have shown the potential for mitomycin C injections to decrease the recurrence of strictures (Bartel et al., 2016), but research has only resulted in prospective studies thus far. Steroid injections have been proven to be ineffective at reducing recurrent stricture rates (Hirdes et al., 2013). All forms of stent placement, biodegradable or expandable, result in adverse reactions for 20-50% of placements (Siersema, 2019). It is also considered the norm for patients to have multiple balloon dilations, proving it to be an impermanent solution. It has been discovered that incisional therapies via electrocautery incisions are effective, but due to the trauma caused by the therapy, it has been noted that this procedure should not be repeated more than 3 times (Hordijk et al., 2006).

Our approach will differ from these current treatments because the examination and exploration of the problem will not only begin with clinical familiarity of the defect, but also computational modeling of esophageal strictures. Using Dr. Haibo Dong's computational software, we will model the esophageal passageway and anastomosis site given input CT images. Analyzing the model will provide important flow parameters, influential biological agents, and areas of high stress within the esophagus. We theorize that areas of high stress will correlate to areas of increased scar tissue growth. We will also use NetLogo software to create an Agent-Based Model of the healing process at the anastomotic site in the esophagus. Both of these models will be used to formulate possible permanent designs to aid in decreasing the recurrence of esophageal strictures

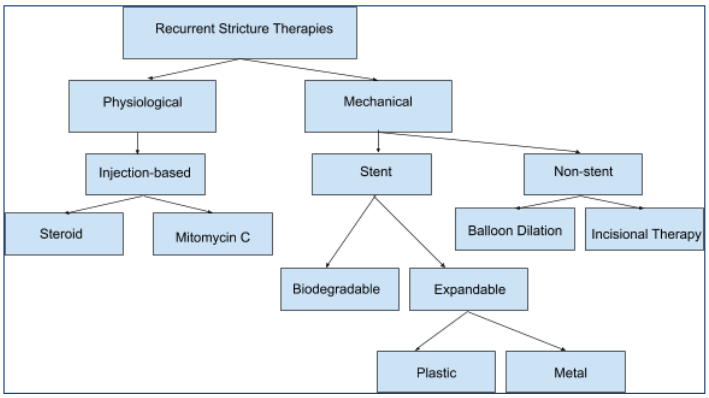

Figure 1. Current therapies and devices available to treat recurrent strictures (Tewari, 2019)

STS Topic

Medical tourism is a growing phenomenon throughout the world. In the past, it typically defined those who traveled from less-developed countries to major medical centers in highly developed countries for treatment unavailable at home (Dalen & Alpert, 2019). Today, patients from all around the world are exercising their autonomy in selecting their health care options by obtaining information from outside their typical health care providers and electing to pursue medical alternatives outside their domestic system. One major influential factor for medical tourism is the healthcare system present within the countries involved. The important institutional characteristics of healthcare, such as cost of insurance, may impact both an individual's desire to travel abroad and the influence that tourism has on each country (Béland & Zarzeczny, 2018). Canada, for example, operating under a universal healthcare system, provides a blanket for individuals requiring emergency procedures. Yet, for non-emergency procedures, citizens in Canada experience long waiting lists, influencing them to travel abroad and pay for a procedure to avoid the long wait periods (Mbadiwe, 2017).

An additional important aspect of medical tourism is the regulation of procedures by the national governments. Specifically, the United States drug and device (DAD) approval system differs greatly to that of European countries. The United States follows a centralized approval

process dictated by only one agency, the Food and Drug Administration (FDA). The European commission, on the other hand, is an assortment of 28 countries designed to protect inter-state commercial interests while preserving national autonomy. While the FDA has the advantages of centralization and common rules, the European Union regulates medical practices through a network of centralized and decentralized pathways. As the United States utilizes one centralized agency, a frequently held assertion is that slower FDA approval and its inherent risk averse nature deprives Americans of DADs that are common to European medical practices. On the other hand, concerns arise that DADs in European countries are approved too quickly, to the detriment of patient safety (Van Norman, 2016). This distinction contributes to American citizens taking advantage of controversial procedures allowed in European countries, and European citizens traveling to America to undergo low risk and highly safe procedures.

Understanding the industry of medical tourism requires analysis of all potential stakeholders. From the United States perspective, the stakeholders are the FDA, local, state, and national government, healthcare insurance companies, health service providers, tourism service providers, Chamber of Commerce, pharmaceutical companies, private and public hospitals, investors, and patients (Jabbari et al, 2013). The stakeholders present for European countries are similar to those of the United States, but include the European Union as an overarching stakeholder that dictates the actions of 28 European nations. Each stakeholder has a broad influence and agenda on the medical tourism industry within their nation. The major artifacts are the different drugs, devices, and medical practices that are approved in certain countries, and disapproved in others. These contribute to individuals partaking in medical tourism to benefit from approved treatments in other countries.

To address how healthcare systems influence medical tourism and the impact of national regulations on approved medical practices, I plan to use Actor-Network Theory (ANT). This framework is a method to map the relationships of people, organizations, objects, and influencers on each other and the broader network. The network defines the relationships each entity has with one another (Cressman, 2009). Numerous stakeholders and artifacts involved in the vast discussion of medical tourism and healthcare play significant roles in supporting the network of medical tourism. They all have minor relationships with one another and interact regularly, directly bolstering the network. The 'Blackbox' present within ANT will represent the bureaucracy of the healthcare systems, which will be further analyzed throughout the course of the study.

As a controversial and highly debated framework, ANT has been highly criticized for its assumptions. ANT relies on the agency and relationships between all actors in a network, many of which are nonhuman objects. Critics of ANT maintain that properties of intentionality and agency fundamentally distinguish humans from non-humans. An additional critique of ANT is that it may imply that all actors in a network are of equal importance. ANT fails to account for pre-existing structures, such as power or bureaucracy, but rather views these as structures emerging from actors within the network ("Criticism of Actor-Network Theory," 2010).

The implications of this research are broad and applicable to individuals around the world. In the political and social sphere, healthcare is an incredibly controversial debate topic, with many countries falling on different ends of the privatized-universal healthcare spectrum. Understanding how a country's inherent healthcare system acts for or against medical migration can shed light on the financial impact from tourism and the potential need for national healthcare reform. Additionally, the prevalence of tourism suggests a significant percentage of the

population whose health depends on the medical practices within other countries. Analyzing individual accounts of their experiences traveling abroad for medical benefits and their personal reasons for doing so can help medical practitioners and national health organizations determine the level of success of medical tourism (Ren et al, 2017). This can lead to policy change either supporting or opposing the autonomy of citizens choosing foreign health care options.

Research Methods and Questions

This study will analyze a two part research question: How impactful are national Drug and Device regulations and the bureaucracy of healthcare systems on the prevalence of medical tourism? Is medical tourism beneficial to individuals? To analyze the first research question, I will utilize documentary research methods. Through this method, I will analyze the current literature surrounding healthcare systems and medical tourism, and look to verify its credibility. With that confirmation, I will use documentary research methods to support the interpretation that various healthcare systems are an indirect proponent for medical tourism (Ahmed, 2009). Additionally, I will analyze current literature on national drug and device regulations to confirm that regulations are the major driving force for individuals with the financial means to engage in medical tourism.

To investigate the success of medical tourism, I will utilize historical case studies. Medical tourism is an active area of investigation for numerous health care affiliates and investors due to the widespread economic impact. Therefore, many medical tourism examples have been studied, allowing me to extrapolate the individual medical cases for a larger case study investigating the overall success rate and level of satisfaction patients felt throughout the process (Widdersheim, 2018).

Conclusion

The objective of the technical study is to reduce the frequency of hospitalization readmission for patients experiencing esophageal stricture post corrective-surgery, through design of a mesh stent to act as a long term dilation device or a cellular engineering technique that is biocompatible with the surrounding tissue. Repeated esophageal stricture within young and developing patients can lead to significant developmental consequences due to both digestive failures and frequent hospitalizations. Improving upon the existing methods will drastically improve the standard of living for patients with esophageal stricture and can expand to help treat stricture in other body tissues, such as the colon and urethra.

The STS study will investigate the influence of healthcare systems and national regulations of health practices on medical tourism and determine if medical tourism is truly beneficial in helping individuals receive optimal care. Perceiving how a nation's healthcare system acts for or against departure for medical reasons can shed light on the financial impact from tourism and the potential need for national healthcare reform. Additionally, the popularity of tourism suggests a significant percentage of the population whose health depends on the medical practices within other countries. I anticipate that while healthcare systems may be attempting to oppose medical tourism, they instead act as an indirect proponent. Furthermore, I believe medical tourism will be shown to be a beneficial supplement to the domestic health care options.

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