Computational Flow Dynamics Analysis of Pelvic and Abdominal Veins Using CT, Venography, and Duplex Ultrasound Imaging
(Technical Paper)

A Sociotechnical Analysis of College Alcoholism.

(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

By
Jessica Cornthwaite
November 1, 2021

Technical Team Members:
Katherine Byrd
Katherine Dunn

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.

John F. Angle, M.D., Division of Interventional Radiology
Hideyuki Torikai, M.D., Visiting Professor in Interventional Radiology
Haibo Dong, Ph.D., Associate Professor in Mechanical and Aerospace Engineering
Yu Pan, Graduate Student in Mechanical and Aerospace Engineering

Bryn Seabrook, Ph.D., Department of Engineering and Society
Timothy Allen, Ph.D., Department of Biomedical Engineering

Prospectus

Introduction

Lower deep vein thrombosis (DVT) is a common, but fatal condition, with estimates as high as 100,000 deaths per year in the United States (U.S.). DVT is a condition where blood clots in a deep vein causing partial or complete blockages in blood flow and irregular flow patterns (CDC, 2020). The clot that forms is clinically referred to as a thrombus, which is a collection of platelets, proteins and other cells (*Definition of Thrombus - NCI Dictionary of Cancer Terms - National Cancer Institute*, 2011). Patients who suffer a DVT may experience intense leg pain and swelling, but many patients are asymptomatic. In the process of diagnosing patients with DVT, various imaging modalities are utilized such as CT scans, venography and ultrasound in order to confirm the presence of DVT. The current treatment for patients with DVT is a cumbersome procedure involving angioplasty stent placement to rid of the venous occlusion and improve blood flow. Primary patency of the venous stent in the first 6 months following the venous stenting procedure is between 80-90% (Razavi et al., 2015). The exact mechanism for formation of venous stent stenosis is still unclear. Many patients who received stenting treatments develop stenosis, even after the occlusion was originally cleared out. The proposed technical project is an analysis of data obtained from the various imaging modalities as well as intravascular ultrasound and pressure measurements, from patients with DVT, will contribute to the development of a computational flow dynamics model of the lower extremity venous anatomy, to understand the contribution of flow rates and patterns on the formation of DVT and recurring stenosis.

A common cause or contributing factor to an increased risk for DVT formation is consuming excessive amounts of alcohol, which is known to increase the number of platelets

present within the blood, increasing the likelihood of random clotting (*How Alcohol Impacts the Risk of Blot Clots*, n.d.). Excessive alcohol intake is a common practice in many U.S. colleges and universities, which provides purpose for a segue to an analysis of the various contributing factors and their influence on the presence of college alcoholism and binge drinking in the U.S. The contributing factors that have the highest impact on colleges students, typically between the ages of 18 and 22, are their environmental and personal factors. Given that four out of five college students and two out of four colleges students consume alcohol to some degree or partake in binge drinking, respectively, it would be helpful to understand how college students' immediate situation and surroundings influence the presence of college alcoholism and binge drinking. With a better understanding of the influence of these environmental and personal factors, it is plausible to use the information obtained to develop more effective intervention and prevention programs in U.S. colleges.

Computation Flow Dynamics Analysis of Lower Extremity Veins

Lower extremity deep vein thrombosis (DVT) affects as many as 900,000 people in the United States per year and is fatal to 10-30% of patients within the first month after their diagnosis (CDC, 2020). DVT is a clinically challenging condition where a blood clot (known as a thrombus) forms in the lower extremities, typically in the common or external iliac veins found within the abdominal and pelvic regions of the venous system (*Definition of Thrombus - NCI Dictionary of Cancer Terms - National Cancer Institute*, 2011). The blood clot formation causes blood flow irregularities as well as partial or complete blood flow blockages, which can be very problematic for patients. These abnormalities in blood flow patterns cause many patients to experience leg pain and swelling, however a large number of patients with a DVT are asymptomatic, estimated up to 50% of patients (Bruni-Fitzgerald, 2015). In order to diagnose a

patient with a DVT, clinicians utilize computerized tomography (CT) scans, venography, and duplex ultrasound imaging to confirm thrombus formation. The current treatment for DVT is a procedure utilizing balloon angioplasty to place a meshed metal stent into the occluded vein, which is supposed to improve blood flow through the body. However, in one study performed, the stenting procedure was successful in the first 6 month following the procedure in 80-90% of patients (Razavi et al., 2015). Therefore, it was determined that the exact mechanism for formation of venous stent stenosis is still unclear. In many patients who received stenting treatments develop stenosis, even after the occlusion was originally cleared out. One of the advisors of this research project, Dr. Torikai, noticed in CT and venography scans that there was a higher tendency for the thrombus to occur on the lesser curve side as opposed to the greater curve side, which has the potential to provide insight into the mechanism behind DVT formation.

The goal of this project is to analyze data from CT, duplex ultrasound, venography, intravascular ultrasound and pressure measurements from patients with DVT to develop a computational flow dynamics (CFD) model of the lower extremity venous anatomy and to understand the contribution of flow rates and patterns on the formation of DVT. The project will be completed as a group of three students including myself and two additional Biomedical Engineering undergraduate students. In order to accomplish this goal, clinical data from CT scans will be used to reconstruct patients' common or external iliac veins with volume rendering to create a 3D model. This model will then be used to run simulations of blood flow. To run these simulations, we must identify the appropriate and most significant parameters to consider. We will then verify our model with clinical data as well as analyze blood flow in patients with DVT and healthy patients. Modeling individual patient anatomy of patients will potentially allow us to determine why stent stenosis occurs more frequently in the lesser curve of the iliac vein.

Using imaging techniques to then build computational models of venous flow may provide insights into why stenosis is more likely to occur in specific regions of the iliac vein. By modeling the iliac vein, clinicians can potentially predict where stenosis may occur. Specific patient models may be used in the future to improve prognosis for DVT patients. Insights on flow after venous stenting may provide insights towards optimizations for stent placement and size. Modeling also provides a non-invasive method to predict the patency of the stent post-insertion. Modeling blood flow in DVT patients is significant for improving surgical outcomes and improved patient care.

A 3D computational model of the iliac vein will be created using imaging data to gain insight on blood flow in the pelvic and abdominal regions. Modeling then will be conducted with ANSYS simulation software in conjunction with blood velocity data from patient sonography to determine flow properties. Flow analysis will be conducted to compare flow patterns and properties in both normal and pathophysiological states. Parameters for proper modeling will be selected based on significance to the flow and physiology of the iliac vein. Clinical data from dynamic CT, venography, and duplex ultrasound imaging modalities will then be used to construct an individualized CFD model of the pelvic and abdominal veins. The outputs of such models can be used to analyze flow in the context of stent stenosis and DVT formation, aiding clinicians in determining if patients are at high risk for stenosis. The final deliverable of the proposed technical project will be described, in-detail, in a technical report document as part of our undergraduate thesis portfolio.

Influence of Contributing Factors on Prescence of College Alcohol Abuse

Alcohol abuse and binge drinking are two common, yet problematic, practices among college aged students in United States (U.S.) universities, as it seems these practices have become more ritualistic to a 'proper' college education experience. In a national survey more

than half, 53%, of college students between 18 and 22 had drank alcohol in the past month and 33% of those students had engaged in binge drinking (*College Drinking Facts for Parents*, n.d.). For a better understanding, alcohol abuse is defined as a habitual overuse of alcohol, while binge drinking involves consuming an excessive amount of alcohol within a short timeframe (*College Alcoholism*, n.d.). The public health concerns regarding overconsumption of alcohol involve the alcohol - related consequences of students' actions as well as the quantity and frequency of intake. Students' consumption of excessive amounts of alcohol can have detrimental effects on their quality of education, life, and health status. In one survey, it was reported that 1 in every 4 every four students have academic difficulties as a result of drinking, including missing class, failing exams or missing assignments (*College Drinking*, n.d.). Not only can alcohol abuse and binge drinking disrupt their academics, it can also decrease their quality of life by making them feel ill, initiate mental health issues or facilitate poor sleeping habits ("6 Effects of Alcohol on College Students," 2019). An abuse of alcohol can detrimentally effect students' health by increasing their risk for assault/injury, result in alcohol poisoning or disrupted homeostasis (*Drinking Too Much Alcohol Can Harm Your Health. Learn the Facts | CDC*, 2021). Although the consequences of alcohol abuse are obvious, the connections between influential factors and college aged students' abusive use of alcohol are unclear. As drinking becomes more common in everyday life, more students are developing problematic drinking habits even before they enter college, which typically becomes exacerbated during college, potentially influenced by two types of factors: environmental and personal.

The influences of various environmental and personal factors on college alcoholism and binge drinking are significant, given that these factors are an immediate result of the students' situation or surroundings. Various environmental factors such as, students' increased

independence, their exposure to peer pressure and an increased alcohol availability have led to an increase use of alcohol, likely due to an influence on students' attitude and drinking habits (*Underage Drinking | National Institute on Alcohol Abuse and Alcoholism (NIAAA)*, n.d.). In addition, there are several personal factors that also influence the presence of alcoholism and binge drinking among college aged students that include, their family history of alcoholism, their stress levels as well as their mental health status. The impact of these factors on the presence of college alcoholism and binge drinking is essential to better understanding the very common practice. One potential use of the information gained from understanding the influence of environmental and personal factors on alcohol abuse, is by using it to shape more effective prevention and intervention programs. Currently, reports on the effectiveness of prevention and intervention programs is insufficient and inconclusive, which gives purpose to performing a research study to better understand the influential factors that would serve to develop more effective programs (*Alcohol Alert #58*, n.d.; *Alcohol and Other Drug Prevention on College Campuses: Model Programs*, n.d.).

Given the likely complex interactions that will arise as a result of making connections between various environmental and personal factors contributing to the presence of college alcohol abuse, a framework that helps to make these connections clearer would be useful in this analysis. As such, utilization of Social Construction of Technology (SCOT), with alcohol representing the technology, will be helpful in mapping the various stakeholders involved in understanding the influence of environmental and personal factors on alcohol abuse, such as the students' themselves, their friends, professors, families, the school, medical professionals, law enforcement and many more. The framework, originally introduced by British Sociologist Trevor Pinch and Dutch Philosopher Wiebe Bijker, can be described in more general terms as,

"A concept or perception of something based on the collective views developed and maintained within a society or social group; a social phenomenon or convention originating within and cultivated by society or a particular social group, as opposed to existing inherently or naturally" (*SOCIAL CONSTRUCT English Definition and Meaning | Lexico.Com*, n.d.). SCOT will be used as an interactive sociotechnical process used to understand how human action shapes alcohol abuse within U.S. colleges and universities. A large criticism of SCOT, from interdisciplinary researcher Stuart Russell, is that as a framework, it fails to recognize the possible connections between relevant social groups and other important parts of society including economic, political and cultural structures (Russell, 1986). However, in order to analyze the multifactor problem that the presence of college alcohol abuse presents, a framework with the perspective that technology does not shape humans, rather human action shapes technology, alcohol in this case, would be helpful in better understanding the connections between students' immediate environmental and personal factors and their drinking habits.

Research Question and Methods

Research question: How do various environmental and personal factors influence the presence of college alcoholism and binge drinking in the U.S.?

In the analysis described in detail above, Documentary Research Methods will be used as a research methodology, along with a discourse analysis, to construct an organized and logical argument. Scientific literature, medical blog posts and survey results will be used in the analysis to pull data from a variety of sources. Scientific literature will specifically be used to portray the accepted understanding of the influence of environmental and personal factors on college alcoholism as well as to conclude on statistics such as prevalence of alcohol abuse and binge drinking among U.S. colleges. Secondary literature sources, such as medical blog posts and

editable reviews, will be used to convey the perspective of other professionals who give their personal opinion on college alcohol abuse. Various survey results will be used, primarily to study the reported alcohol-related consequences that arise for students. Specific keywords that will be used to conduct research on this topic include: college alcoholism and binge drinking, environmental factors on alcoholism, personal factors on alcoholism as well as alcohol prevention and intervention strategies. An in-depth analysis of the information provided in these sources will be supplemented with Documentary Research Methods and a discourse analysis, in order to combine the information from the various sources and draw conclusions regarding the influence of contributing factors on the presence of college alcoholism and binge drinking.

Conclusion

Outlined in this document are two projects: a technical design project and an STS research paper. The former involves a thorough analysis of various imaging modalities including, computerized tomography (CT), venography and duplex ultrasound, to model abdominal and pelvic veins from clinical data for computational flow dynamics (CFD) analysis to better understand blood flow irregularities in patients with deep vein thrombosis (DVT). With a currently complex treatment protocol, involving balloon angioplasty for stent placement, it would be beneficial to determine the significant parameters that contribute to DVT formation and recurring stenosis in patients. The results of the projects will provide insights into more effective placement protocols for stents, an ability to better predict the likelihood of stenosis, as well as improve patient care.

To expand of the latter of the two projects mentioned, the STS research paper describes an analysis of the various environmental and personal factors and their influence on the presence of college alcoholism and binge drinking, a now very common practice among U.S. colleges and

universities. With the high prevalence and potentially serious alcohol-related consequences that arise as a result of students' actions with alcohol, a better understanding of how various factors influence students' abusive use will provide better insights into developing more effective intervention and prevention programs for colleges. This research will serve to provide readers a clear and concise analysis of how various factors contribute to alcohol abuse among college aged students, as well as provide potential ideas for appropriate intervention and prevention programs/situations. The information provided will be used to develop effective programs that maintain students' quality of a 'college experience,' while also helping to avoid the related consequence of alcohol abuse.

References

6 Effects of Alcohol on College Students. (2019, May 7). *The Haven at College*.

https://thehavenatcollege.com/effects-of-alcohol-on-college-students/

7 Causes And Risk Factors For Alcoholism. (n.d.). *Vertava Health Ohio*. Retrieved October 26,

2021, from https://vertavahealthohio.com/alcohol/7-risk-factors/

Alcohol Alert #58. (n.d.). Retrieved October 27, 2021, from

https://pubs.niaaa.nih.gov/publications/aa58.htm

Alcohol and Other Drug Prevention on College Campuses: Model Programs. (n.d.). 46.

CDC. (2020, February 12). *Data and Statistics on Venous Thromboembolism | CDC*. Centers for

Disease Control and Prevention. https://www.cdc.gov/ncbddd/dvt/data.html

College Alcoholism. (n.d.). Alcohol Rehab Guide. Retrieved October 24, 2021, from

https://www.alcoholrehabguide.org/resources/college-alcohol-abuse/

College Drinking. (n.d.). 4.

College Drinking Facts for Parents. (n.d.). Retrieved October 30, 2021, from

https://www.collegedrinkingprevention.gov/parentsandstudents/parents/FactSheets/Parent

FactSheet.aspx

Cressman, D. (2009). A Brief Overview of Actor-Network Theory: Punctualization,

Heterogenous Engineering & Translation. https://summit.sfu.ca/item/13593

Definition of thrombus—NCI Dictionary of Cancer Terms—National Cancer Institute

(nciglobal,ncienterprise). (2011, February 2). [NciAppModulePage].

https://www.cancer.gov/publications/dictionaries/cancer-terms/def/thrombus

Drinking too much alcohol can harm your health. Learn the facts | CDC. (2021, May 11).

https://www.cdc.gov/alcohol/fact-sheets/alcohol-use.htm

How Alcohol Impacts the Risk of Blot Clots. (n.d.). Alcohol.Org. Retrieved October 26, 2021, from https://www.alcohol.org/effects/blood-clots/

Razavi, M. K., Jaff, M. R., & Miller, L. E. (2015). Safety and Effectiveness of Stent Placement for Iliofemoral Venous Outflow Obstruction: Systematic Review and Meta-Analysis. *Circulation. Cardiovascular Interventions*, *8*(10), e002772. https://doi.org/10.1161/CIRCINTERVENTIONS.115.002772

Russell, S. (1986). The Social Construction of Artefacts: A Response to Pinch and Bijker. *Social Studies of Science*, *16*(2), 331–346. https://doi.org/10.1177/0306312786016002008

SOCIAL CONSTRUCT English Definition and Meaning | Lexico.com. (n.d.). Lexico Dictionaries | English. Retrieved October 31, 2021, from https://www.lexico.com/en/definition/social_construct

The Effects of Environmental Factors on Alcohol Use and Abuse. (n.d.). Retrieved October 3, 2021, from http://www.alcoholpolicymd.com/alcohol_and_health/study_env.htm

Underage Drinking | National Institute on Alcohol Abuse and Alcoholism (NIAAA). (n.d.). Retrieved October 3, 2021, from https://www.niaaa.nih.gov/publications/brochures-and-fact-sheets/underage-drinking