Computational Fluid Dynamic Analysis Of Pelvic And Abdominal Veins Using Computed Tomography, Venography, And Duplex Ultrasound Imaging

Health Concerns for People Who Depend on Food Assistance

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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.

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Prospectus

Deep Vein Thrombosis and Health of People on Food Assistance Programs

Deep vein thrombosis (DVT) occurs when a blood clot forms in one or more of the deep veins in your body, usually in your legs. Factors such as age, prolonged bed rest, injury or surgery, obesity, smoking status, cancer, and more can increase your risk for developing a DVT blood clot (Mayo Clinic Staff, 2020). Our technical project is based on a pattern that was noticed on computed tomography (CT) scans in which clotting was almost always occurring on the lesser (inside) part of the curve in the iliac vein. Our project seeks to determine whether someone's specific venous anatomy puts them at a higher risk of developing a DVT blood clot. For patients who are at higher risk of developing DVT due to their risk factors or those who have had a previous DVT, stent placement could help prevent subsequent occlusions. To best place a stent, a computational fluid dynamic (CFD) model that our technical project aims to create will allow clinicians to better understand blood flow inside their specific patient's veins based on where they place the stent.

Modeling Deep Vein Thrombosis Using Computational Fluid Dynamic Analysis

Deep vein thrombosis (DVT) is a medical condition that occurs when a blood clot forms in a deep vein (CDC, 2020). Lower extremity DVT affects 200,000 people in the U.S. each year and is a clinically challenging condition where a blood clot (known as a thrombus) forms in the lower extremities, typically in the common and iliac veins found within the abdominal and pelvic regions (Patel, 2019; NCI, 2011). Anatomical differences can predispose people to developing a DVT blood clot. Once a person has previously suffered from a DVT of either partial or complete blockages of their vein, they are at a higher risk for developing subsequent DVT clots. The formation of a blood clot causes blood flow irregularities as well as partial or complete blood flow blockages, which can be very problematic for patients. The blockages can lead to leg pain, swelling, serious illness, disability, and even death (CDC, 2020). However, up to an estimated 50% of patients with a DVT blood clot are asymptomatic (Bruni-Fitzgerald, 2015). In order to diagnose a patient with a DVT, clinicians utilize CT scans, venography, and ultrasound imaging to confirm thrombus formation (Karande et al., 2016). The current treatment for DVT is a procedure utilizing balloon angioplasty to precisely place the stent into the occluded vein, which functions to improve blood flow through the body. However, in one study performed, the stenting procedure was successful in the first six months following the procedure in 80-90% of patients (Razavi et al., 2015). The exact mechanism for the formation of venous stent stenosis (occlusion of the stent) is still unclear. Many patients who received stenting treatments develop stenosis, even after the orginial occlusion has been cleared.

The goal of this technical project is to analyze data from CT, duplex ultrasound, venography, intravascular ultrasound and pressure measurements from patients with DVT to develop a computational fluid dynamic (CFD) model of the lower extremity venous anatomy and to understand the contribution of blood flow rates and patterns on the formation of DVT. In order to accomplish this goal, we will be using de-identified patient CT data to reconstruct of the iliac vein with volume rendering to create a three-dimensional 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 has the potential to 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. These results can be used to further improve surgical outcomes and improve overall patient care.

A three-dimensional computational model of the iliac vein will be created using imaging data to gain insight on blood flow in the pelvic and abdominal region. 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.

Health Concerns for People Who Depend on Food Assistance

While the focus of my technical project is to create a model to predict patients who are at high risk for DVT, the balance of my paper will explore health concerns of people who depend on food assistance programs. There were nearly 44 million people in the United States (U.S.) on food assistance costing nearly $90 billion in 2020 (Evich, 2021). Food assistance programs were first established in the U.S. in the late 1930s to help reduce surplus foods as well as alleviate food insecurity in Rochester, New York (Klein, 2019). Nationally, food assistance programs such as the supplemental nutrition assurance program (SNAP) participants benefit families with children (Hall, 2021). There are many negative effects related to food insecurity in young children such as increased hospitalizations, poor health, iron deficiency, developmental risk and behavior problems (Black, 2012). Children who do not get sufficient nutrients are at higher risk for anemia and asthma (Feeding America, 2021). Using the framework of technological momentum, I will show how reverse salients and system builders have socially constructed and shaped society around health concerns for people who depend on food assistance.

I will analyze this topic using the framework of technological momentum as described by Hughes (Hughes, 1987). Reverse salients are the components of a technological system that impede on its own growth and fulfillment of goals set for it while system builders are an entity or group that invents, develops, and innovates artifacts and technological, organizational, and social infrastructure for the purpose of solving a problem. The system of food assistance can be seen as a reverse salient because although it is meant to help people who cannot afford to purchase food for them and their families, if it does not provide foods which are nutrient rich it impedes itself. It would not be allowing for greater acess to quality meals for those who cannot afford it otherwise, which is the main goal of having food assistance programs.

People who qualify for food assistance through the SNAP must have a gross monthly income at or below 130% of the poverty line, net income at or below the poverty line, and assets below set limits (Center on Budget and Policy Priorities, 2021). States with the highest rates of SNAP recipients are New Mexico with 21% of their residents participating, followed by

Louisiana and West Virginia which both have 17% of residents recieving SNAP (World Population Review, 2021). Food insecurity has been linked to chronic diseases as it promotes dependence on inexpensive foods that are energy, but not necessarily nutrient, dense (Laraia, 2013). SNAP is substantially reduces food insecurity and therefore is critical to reducing negative health outcomes (Gundersen & Ziliak, 2015).

Nutrient rich diets contain many vitamins, minerals, and few calories while also being low in sugar, sodium, starches, and bad fats (NCI, 2011). SNAP can be used to purchase fruits, vegetables, meat, poultry, fish, dairy products, breads, cereals, snack foods, non-alcoholic beverages, seeds and plants to grow your own food (Food and Nutrition Service, 2021). People who created food assistance programs can be seen as system builders because they set up a program to reduce food waste while providing higher quality food at a lower cost to those who otherwise could not obtain it.

Can Those on Food Assistance Programs Have Nutrient-Rich Diets?

My research question is in what ways do food assistance programs contribute to a nutrient-rich diet? I will collect data through interviews with food bank directors and through policy analysis of legislation that funds food assistance programs. Examples of questions I will ask food bank directors include:

1. What percent of the food your program provides are fresh fruits and vegetables?
2. What percent of food from United States Department of Agriculture (USDA) is nutrient rich?
3. What are the main ways you acquire nutrient rich foods, such as fresh fruits and vegetables?

As for policy analysis, I will look at the history of the SNAP (Food and Nutrition Service, 2018). This will allow me to analyze how the first food stamp program helped feed the under-nourished by allowing them to purchase surplus food as determined by the USDA at half the cost. One of the official purposes of the Food Stamp Act of 1964 was to provide improved levels of nutrition among low-income households. In a study comparing those who were SNAP-eligible participants, SNAP-eligible non-participants, and SNAP-ineligible non-participants, they found that sugar-sweetened beverage (SSB) consumption had dropped from 2003 to 2009 while it had remained the same among SNAP-eligible participants and that SNAP participants consumed more SSB calories compared to SNAP-eligible non-participants (Nguyen & Powell, 2015). Through the use of studies like this, I will determine the effects of relying on food assistance programs on the ability to maintain a nutrient rich diet.

Conclusion

Creation of a three-dimensional computational flow dynamic model will allow physicians and other clinical care team members to hopefully prevent deep vein thrombosis in patients who they believe are at an elevated risk of developing a DVT blood clot. They could use the technology to help the 200,000 people that are affected by DVT each year in preventing subsequent DVT blood clots by creating a more precise method based on blood flow patterns to place stents. In the socio-technical portion of my research paper, I will argue that those recieving food assistance through SNAP can have nutrient rich diets due to the system builders and reverse salients that the program enforces.

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