Balloon-Stent Endovascular Device for the Treatment of Intracranial Aneurysms

Postmortem Analysis

Team Number: 21Spr02

Dallany Segura

Danny Castano

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Project Sponsor: Bioengineering Devices Laboratory (BDL)

Faculty Advisor: Dr. Timothy Becker

Sponsor Mentor: Omid Asgari, PhD student in Bioengineering

Instructor: Senior Lecturer David Willy

I. Introduction

The following document contains the postmortem analysis, which entails the reflection and evaluation of the project outcomes from the Spring 2021 semester in order to establish an effective plan of action to be used for the remainder of the capstone project. The team discusses the expectations stated in the team charter and determines the effectiveness of the ground rules and coping strategies that were followed. The methodologies used are explained to identify the positive and negative aspects of the project performance. The reflection on the team strategies and project performance practices outlines the areas of improvement which allows the team to develop specific actions for success in future work.

II. Contributors to project success

The team charter states the purpose of the project is to design, analyze, and prototype a balloon-stent device to be used in the treatment of brain aneurysms. So far, the team has designed a mesh grid stent in SolidWorks and a cylindrical balloon. These two components have dimensions that allow them to fit concentrically, with the balloon surrounding the stent. The progress made so far does satisfies the goal made in the team charter, as our design is innovative and works well to satisfy the engineering requirements of the balloon-stent. However, specific details of our design are still to be refined, such as the weave pattern of the stent, and how the assembly would connect to the microcatheter. In addition to the necessary design improvements, the woven stent design must be prototyped using the appropriate material, nitinol.

The team charter also laid out ground rules and coping strategies that the team would abide by. The ground rules stated in the charter include: First, addressing fellow teammates in a professional and respectful manner. Second, to discuss potential issues or setbacks as soon as they become apparent to ensure that the team has enough time to figure out a possible solution. Third, each member is to contribute an equal amount to the total workload, and to assist other teammates as necessary. Overall, the team did a good job of following these ground rules. As the semester progressed, the team members got to know each other better and developed a mutual respect, which naturally caused the team to abide by these rules. The team addresses each other with respect and did their best to deal with obstacles in a timely manner. Furthermore, according to the total time recorded on each member's timecard, each member contributed an almost equal amount of work to the progression of the project. The coping strategy stated in the charter is meant to deal with difference of opinions or disagreements. It states that if there are any conflicting opinions regarding the project, the team is to meet in person or over Microsoft Teams to discuss a solution or compromise. If the team members are still in disagreement after this discussion, then the team will consult with either David Willy, John Veden or the client, Tim Becker, for their professional opinion. This coping strategy was implemented various times throughout the course of the semester, as many differences of options would arise. The team dealt with these by talking through each idea and deciding on a solution. When a solution was still not evident, then we consulted with David Willy and Tim Becker. The ground rules and coping strategies stated in the team charter were effective, so the team will continue to abide by this method to work together.

The aspect of the team's project progression that was most positive was the CAD modeling. The CAD models developed by the team showcased possible design assemblies for both the balloon and stent. At first, the CAD designs were fairly simple, but as the semester progressed the design became more refined. This is particularly evident in our stent design, as it began as a typical cylindrical grid stent and

progressed to become the first variant of a cylindrical weave design. The tool used that primarily contributed to our CAD success was SolidWorks. The method used for the progression of the CAD models was collaborating ideas and combining the team's different skillsets. An aspect of the team's project progress that was negative were the analytical analyses. While Bernoulli's equation was successfully used to theoretically validate the fractional pressure ratio (FPR) given the balloon-stent's diameter, and the change in pressures, where our analysis lacked was in the computational fluid dynamics (CFD) simulations done on ANSYS Fluent. The mesh and boundary conditions were successfully created, but when the simulation ran, an error would prevent the solution from progressing through the needed time steps. The error in question has still yet to be resolved, but hopefully with some guidance from some NAU professors that are familiar with ANSYS Fluent, the team will be able to resolve this error.

III. Opportunities/Areas for improvement

Some problems that the team encountered last semester mostly stemmed from heavy workloads form other classes and having to adjust to a mostly virtual form of collaboration due to COVID-19. Having to deal with other courses often forced us to complete Capstone assignments the night that they were due, which is not ideal. Needing to rush to complete an assignment would often cause the quality to not be as high as the team was hoping for. This only occurred on a couple occasions but could probably have been avoided if the team members were more productive in their other studies so that more time could be devoted to the Capstone assignments. In the future, the team hopes to improve the time management by reviewing and understanding assignments as soon as possible, determining a plan of action, and creating due dates for subsections of the assigned task. The goal for this plan is to continuously work on assignments to allow time for review before the deadline. Additionally, due to COVID-19 shifting the learning paradigm to a more virtual style, the team had to adjust to this as each assignment was highly collaborative. At first this was a challenge, but as the semester progressed, we became acclimated to this new style, and started to understand the beneficial capabilities of coordinating assignments using Microsoft Teams. Similarly, it is anticipated that presentations will shift back to being in person, so the team recognizes that it's important to be mindful of the time it takes for practice presentations.

Some specific organizational actions that the team can implement to improve performance could be creating a schedule of when to meet in person to work on deliverables. With COVID-19 restrictions being less intense than last semester, it will be easier to meet in person (at the Cline Library for example) to work on the deliverable assigned that week, or on any other components related to the project. In person meetings will benefit the team because it allows members to hold each other accountable for staying focused to produce quality work. Furthermore, a schedule for when the team can meet in the Bioengineering Devices Laboratory (BDL) will also prove to be beneficial, as we will be spending more time there than the previous semester. Often times the schedule will have to be adjusted due to certain circumstances, in which the second ground rule would come into effect, where we would reschedule the meeting as soon as possible. In addition to scheduling, the team would benefit from discussing, determining and stating the priority tasks in the capstone project. Due to the intense workload, it can be overwhelming to think about how to complete some assignments, but the workload can be more feasible if the team begins working on the most valuable aspects of each assignment. For example, the next upcoming assignment due is the self-learning assignment, so the team should prioritize collectively

selecting topics that are beneficial to the project. Selecting priorities will help establish a better plan to produce meaningful contributions to each assignment.

Throughout the course of this project, the team has learned a couple important technical lessons. While the CFD simulation is still giving an error, the team has still learned a great deal about fluid dynamics as it applies to the Circle of Willis (CoW) located at the base of the brain. We now know how Bernoulli's equation can be applied to the system when the device is placed within the artery, which causes a pressure difference due to the change in geometry. Furthermore, the team found that the Hagen-Poiseuille equation is appropriate in finding parameters of the blood flow within the CoW. The CoW is a system of blood vessels which creates non-ideal fluid behavior. The equation was deemed reasonable because it considers entropy.

IV. Conclusion

The postmortem analysis is a beneficial tool that allows the team to determine how the performance can be improved in the future. First, the team reviewed the team charter that was developed at the start of the project to be reminded of the purpose of the project and the team's goal. Using this agreement, the team reflected on their success in accomplishing the goal. It was established that the team accomplished the goals during the Spring 2021 semester, but that there was still plenty of room for improvement and refinement, specifically in the development of the woven stent design. Furthermore, the team reflected on the success of the predetermined ground rules and coping strategies. The ground rules and coping strategies were followed and resulted in good teamwork, so the team will continue using this method. The effects of teamwork are shown in the results of the CAD modeling and the analytical analyses. The CAD models were accomplished by sharing ideas and using our different skillsets which resulted in good quality work. The analytical analyses were more independently driven which resulted in the team members learning more about the application of fluid mechanics to the project, but not producing useful results. Based on the reflection of the project progress, the team decided that it would be beneficial to be more proactive about assignments by creating schedules and establishing priorities. The intended goal in using these practices is to have more time to work on and review assignments to ensure quality work.