Senior Design / BS Project
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DynaCath: Cannula Clearing System

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Abstract

Insulin Pump therapy is an increasingly popular regulation method for individuals with type I and type 2 diabetes. In the United States, it is estimated that at over 400,000 individuals use insulin pumps for continuous insulin delivery to maintain healthy glucose levels. Currently, cannulas are only recommended for continuous use up to three days due to risk of occlusion leading to potentially dangerous situations where diabetic individuals do not receive the insulin they need. With the creation of a way to clear the cannula, the life of a cannula can be extended an additional three or more days. Insulin pump infusion sets such as Medtronic Minimed infusion set cost patients between $120 to $200 for a pack of ten infusion sets, lasting approximately one month. The creation of an occlusion clearing device could decrease the personal cost of infusion sets significantly, but most importantly, it could clear a fully occluded cannula in the case of an emergency and allow the patient to resume insulin delivery. This is especially essential, when the patient does not have immediate access or time to insert a new infusion set and would be at high risk of hyperglycemia.

Introduction

Occlusions are caused by insulin deposits or body tissue that form in and around the infusion set catheter, or cannula. This phenomenon produces an increase in pressure that interrupts insulin delivery. Therefore, our device attachment includes a spring-loaded button that pushes a needle gauge into the infusion set and flushes the occlusion. This function will restore insulin delivery and increase the amount of time the infusion set can remain inserted subcutaneously as shown in Figure 1. Additionally, by aligning with and attaching to the infusion set, our device offers users stability and ease when using the device.

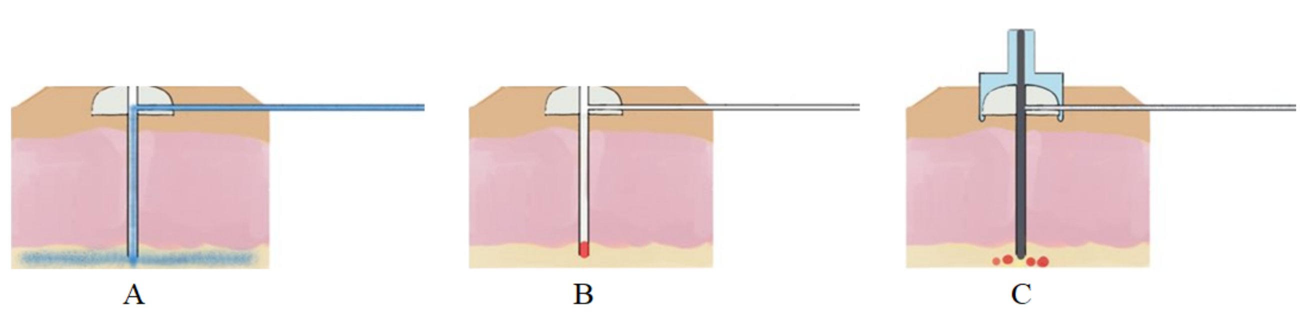

Figure 1: (A) Insulin is delivered subcutaneously via infusion set; (B) Occlusions prevent or lessen insulin delivery; (C) The device flushes the cannula

Methods I Design I Analysis

- Finite element analysis via COMSOL was used to simulate insulin flow through an infusion set.
- We simulated a partial occlusion in the cannula to determine changes in pressure and flow rate.
- We simulated clearing the occlusion with our designed device by subtracting the area of the occlusion by the diameter of the needle gauge and then comparing the pressure profiles for the pre and post cleared cannulas

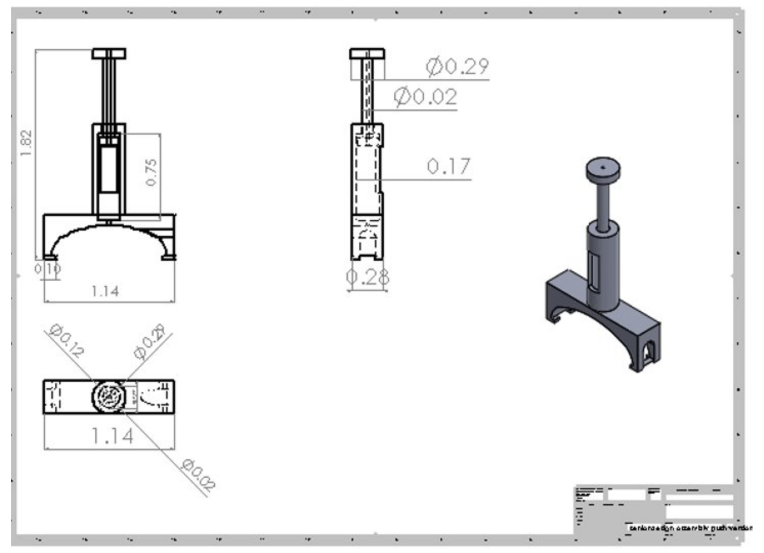

Figure 2: Dimensioned CAD drawing

Figure 3: 3D Printed Device

Results

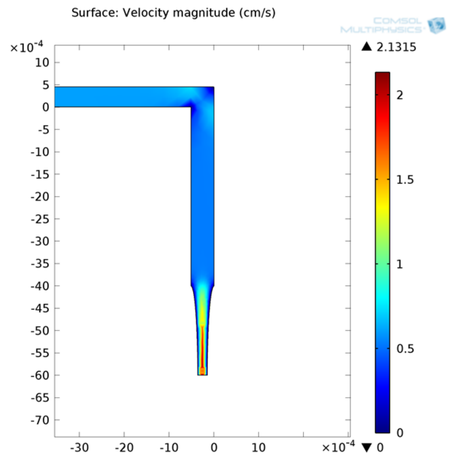

Figure 4: Velocity profile of occluded cannula

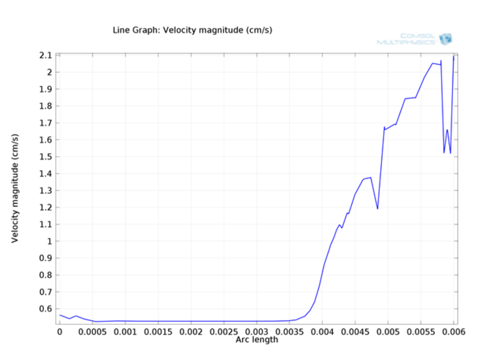

Figure 5: Velocity line graph of occluded cannula

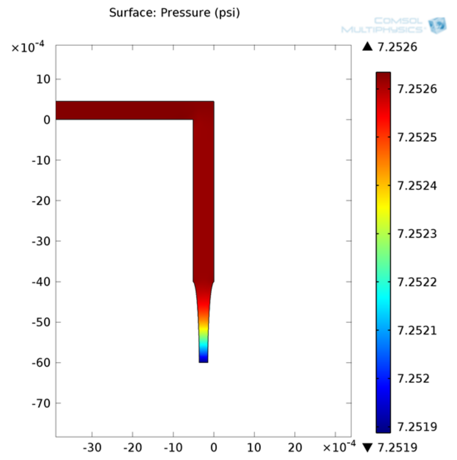

Figure 6: Pressure profile of occluded cannula

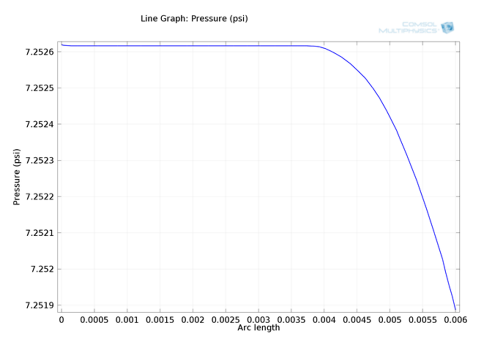

Figure 7: Pressure line graph of occluded cannula

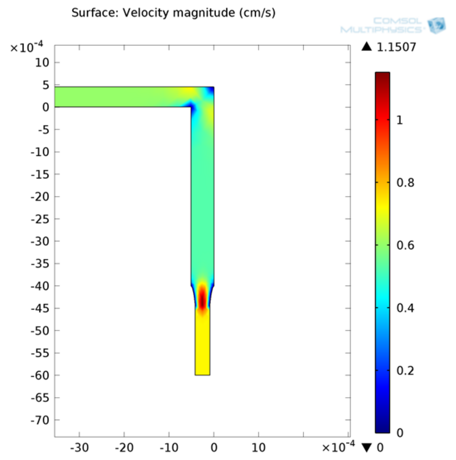

Figure 8: Velocity profile of cleared cannula

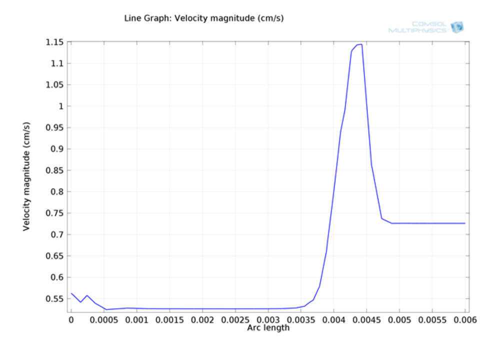

Figure 9: Velocity line graph of cleared cannula

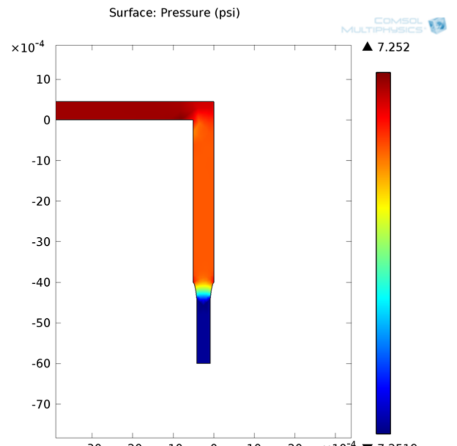

Figure 10: Pressure profile of cleared cannula

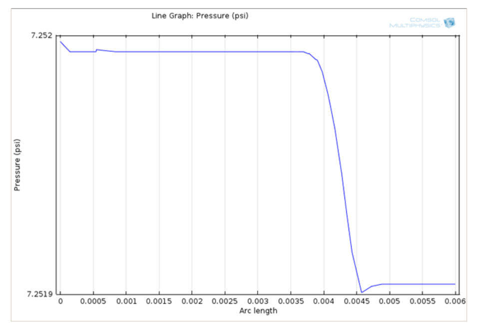

Figure 11: Pressure line graph of cleared cannula

Conclusion

The insulin pump has a built-in pressure gauge which detects any increase in pressure in the cannula due to occlusions and thus decreases the insulin flow to compensate. This results in reduced delivery and hyperglycemia in the patient. Our simulation showed that by clearing the occlusion, the pressure reduced to normal levels, allowing resumed delivery. This device attachment is a well-designed and practical solution for insulin pump users. It's simple mechanical construct yields a unique function that effectively fulfills the design specifications and user requirements. Moreover, our device could not only reduce the incidence of hyperglycemia in insulin pump users, but also can help patients resume the continuous delivery when time or access to supplies are limited.

Acknowledgments

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