Leptin Delivery Device for Type 1 Diabetes Care

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Background

Type 1 diabetes is a chronic condition where the body's immune system attacks insulin-producing cells in the pancreas, leading to little or no insulin production. Insulin is essential for regulating blood sugar levels. Without sufficient insulin, blood glucose levels rise, leading to serious health complications over time, such as heart disease, kidney damage, and nerve damage.Traditional treatments involve daily insulin injections, but managing blood sugar levels remains challenging [1].

Mission Statement

Our mission is to improve diabetes care with an easy-to-use device that supports insulin treatment, helps manage blood sugar, and provides real-time updates for patients.

Timeline

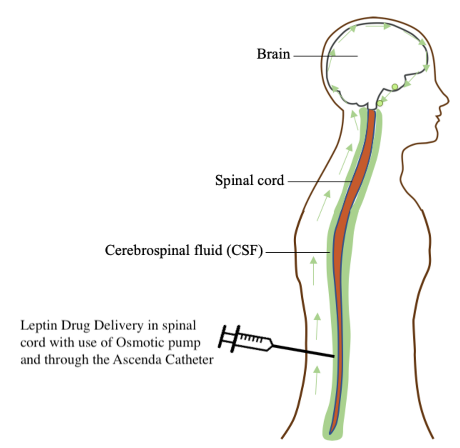
This Gantt chart shows our project timeline, helping us to track progress and keep on track with deadlines efficiently.

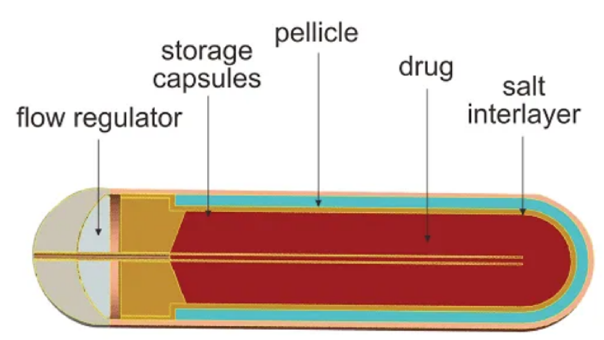
Customer Needs/Metrics

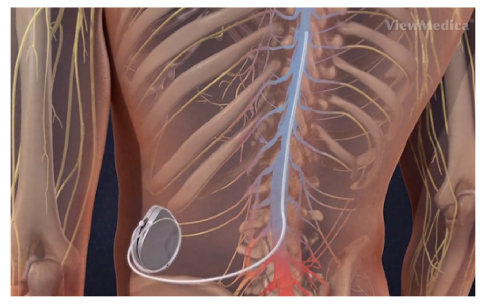
Needs/Metric	Target Value
Accuracy	± 5%
Flow rate	0.002 to 0.003 ml^3/s
Duration treatment	6 months per dosage
Cost of Production	$599
Device life-spam	10 years
Surgical time	30min - 1hr
Infection Rate	≥1.5
Health devices integration	Compatible with 95% of major health devices
Aftermath surgical procedure side affect	Pain scale: 0-4
Delay response	≥ 1ms

House of Quality (HoQ)
It matches what customers want with how a product is designed.

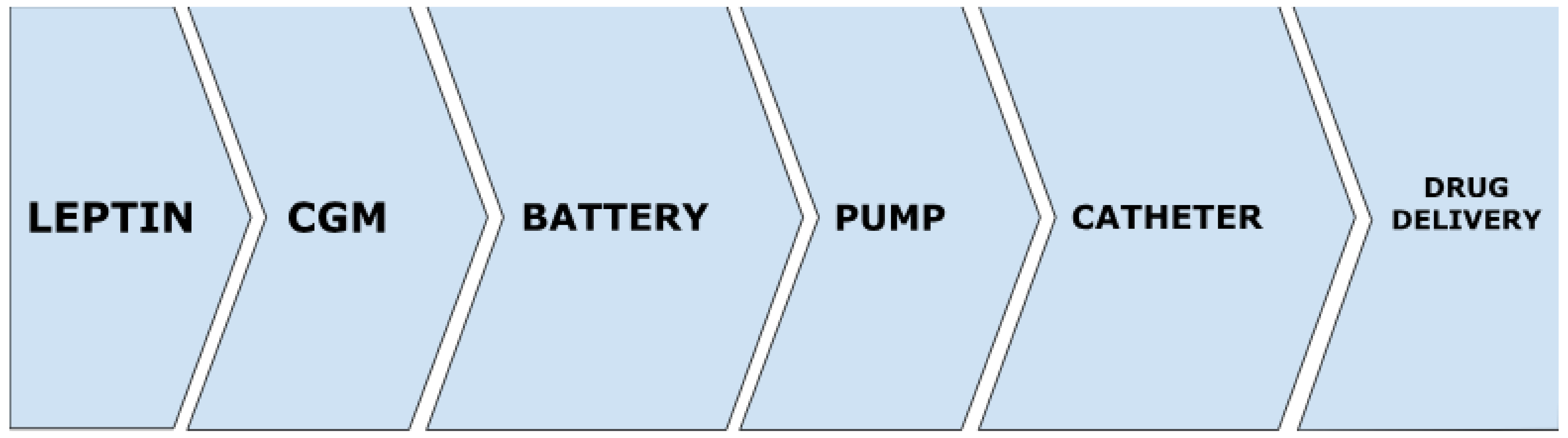
Device Concept and Design







Product Architecture(including technical models)



Equations for Battery life span State of energy (SOE):

$En = U^n * Q^n$ and $E_{SOC}^{remaining}(t) = E^{n*SOC(t)}$

$t^0 = w^0/p^0$ nd $P^0 = \Sigma P_n$

Estimated Average Glucose Level Equation:

A1C(%) = (Estimated average glucose(mg/dL) + 46.7) / 28.7

Volumetric Flow Rate Equation:

$Q = vA$

Flow Rate Equation

$Q=V/t$

Dose Calculation Equation

$D=C\times Q$

Pressure Considerations - Hagen-Poiseuille equation

$\Delta P=8\eta LQ/\pi r^4$

Equation For Osmotic Pump

$Q=(A\times)/R$

$dC/dt=Q/V-k\times C$

Manufacturing

The improved leptin delivery device uses readily available components with minor modifications for enhanced functionality and cost-effectiveness. It includes a 40 cm Ascenda catheter (inner diameter: 2 cm, outer diameter: 4 cm) made of silicone rubber, a 4 cm x 4 mm osmotic pump with an osmotic layer, semipermeable membrane, and sensors, a 50 ml external reservoir, and a lithium iron phosphate battery (85 mm x 12 mm, aluminum oxide coating). The device is powered by modified CGM software for real-time tracking and control. While most components align with existing manufacturing processes, the osmotic pump may require a new manufacturing path, and the battery might need precise sizing from specialized producers. Despite these adjustments, the device is cost-effective, leveraging readily available materials to minimize production expenses. The osmotic pump absorbs fluid, contracts, and delivers the drug via a flow moderator to the Ascenda catheter, ensuring precise delivery to the cerebrospinal fluid (CSF). This efficient, scalable design balances affordability with strong potential for clinical application.

Design Status/Future Work

Our device uses a compact osmotic pump connected to a catheter, making it easy to implant with less discomfort. It delivers controlled doses of leptin, while sensors in the device track its performance. The device is powered by a long-lasting battery, designed to work for up to 10 years, and uses updated coding for smoother data tracking, which patients can see on mobile devices. Future work will focus on making the device even smaller and refining the battery and software for the best patient experience.

Acknowledgements

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References

[1]Mayo Foundation for Medical Education and Research. (2024b, March 27). *Type 1 diabetes*. Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/type-1-diabetes/symptoms-causes/