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Milrinone Alternative Delivery

October, 2, 2026

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Client Information

- Doctor of Osteopathic Medicine (DO)
- Family Practitioner at Stevens Point, WI
- Interested in improving the ease of Milrinone delivery
 - Observed from his brother daily life with congestive heart failure

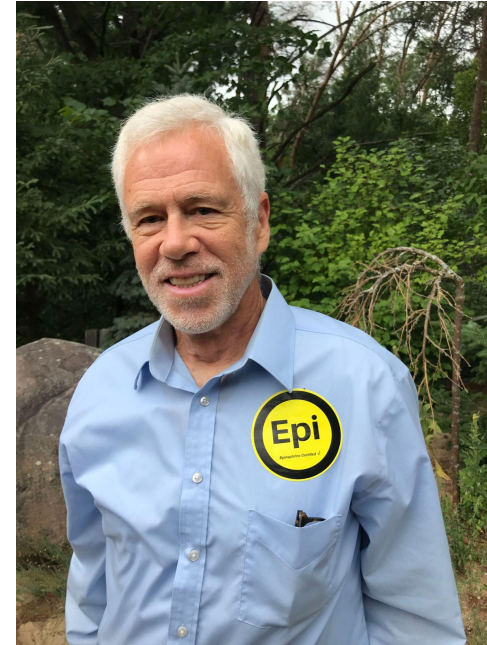


Figure 1 Dr. Markman [1]

Background Information

- Milrinone is used as cardiac support for acute heart failure, pulmonary hypertension, or chronic heart failure [2]
 - Improve cardiac contractility, relaxation, and induce vasodilation [2]
- Currently only available via continuous IV infusion[4]
 - Oral study discontinued due to increased mortality rate [3]
- Therapeutic range: 100 - 300 ng/mL [3]
- No antidote is available [2]
 - Can only stop delivery and treat the symptom accordingly [2]



Problem Statement

- Milrinone is an effective medication for patients with congestive heart failure [2]
- IV is the only approved method of delivery at the moment [2]
 - Complicated instructions and require extra training [6]
 - Risk collapsed vein, hematoma, infection, and infiltration [5]
- Develop alternative, non-invasive delivery methods for Milrinone
 - Enable quick, simple administration by patient or others
 - Eliminate the need for needles
 - Eliminate the need of special training



Product Design Specification

- Performance and Dosing
 - Target patient: Stage D Heart Failure
 - Dosing strategy: 12-hour sustained release profile
 - Dose Accuracy: Dose accuracy within $\pm 2\%$ of nominal weight to ensure concentration stays within therapeutic range and prevents risks such as arrhythmia and severe hypotension
- Stability and Service Life:
 - Shelf life: Up to 3 years sealed at room temperature and 72 hours post-unsealing
 - Durability: Sealed, non-refillable, light and oxygen insensitive
- Physical Characteristics
 - Materials: Gelatin or polymer capsule
 - Target cost: \$126.35
- Regulatory and Standards Compliance
 - FDA approval process: NDA combination product under 21 CFR Part 4
 - Applicable standards: ISO 10993(Biocompatibility), USP <711> (Dissolution), USP <905> (Uniformity), and USP <601>.



Competing Designs

Outpatient

- Pump IV
 - Benefits
 - constant dosage delivery
 - reduces recurrent hospitalization [7]
 - Limitations
 - Inhibits daily mobility
 - Line infections[7]

Inpatient

- Nebulized
 - Benefits
 - cardiac output increase[8]
 - Less invasive
 - Limitations
 - Inhibits daily mobility
 - No studies of Inhaled milrinone in home setting



Design Alternatives Considered for Milrinone Administration

Sublingual Pouches

- Insert the milrinone in a plant-based cellulose fiber pouch.
- Medication enters the bloodstream through gum tissue.
- Compact as to not cause discomfort or irritation within the gums.

Nasal Spray

- Administer the milrinone in a liquid form through the use of a nasal spray.
- Milrinone would be absorbed through the tissue in the nasal passages.
- Allows for a short acting dose of medication, without having to swallow the dosage.

Extended Release Oral Capsules

- The milrinone would be in a gelatin or polymer capsule that would slowly release the medication over a set period of time.
- Extended release could reduce the frequency of medication administration throughout the day.



Design Matrix

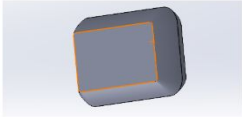
Design	Milrinone Sublingual Pouches	Milrinone Nasal Spray	Milrinone Extended Release Oral Capsules
Criteria (weight)			
Ease of Fabrication (15)	3	2	5
Ease of Use (25)	4	5	5
Cost of Fabrication (15)	5	3	4
# of Dosages per Day (20)	4	2	5
Environmental Impact (5)	2	5	2
Choking Hazard (10)	2	5	1
Comfort When Applied (10)	3	5	4
Total (100)	72	73	84

Figure 2: Design Matrix with criteria and score



Final Design

- Commercial capsule shells are available online with the internal formulation controlling drug release
- A pre-set oral dose could simplify administration process for the patient
- Target dosing interval is every 12 hours, or twice daily.
- The peak dosage should not exceed $0.5\mu\text{g}/\text{kg}/\text{min}$, for a 70kg adult, total intake of the day should be:

$$0.5 \mu\text{g}/\text{kg}/\text{min} * 70\text{kg} * 1440\text{min} = 50400\mu\text{g} = 50.4\text{mg}/\text{day}[9]$$

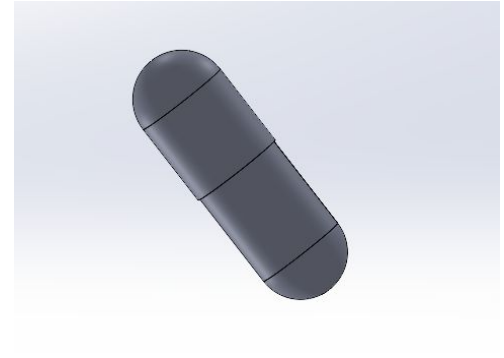


Figure 3: Milrinone Extended Release Oral Capsules



Future Work

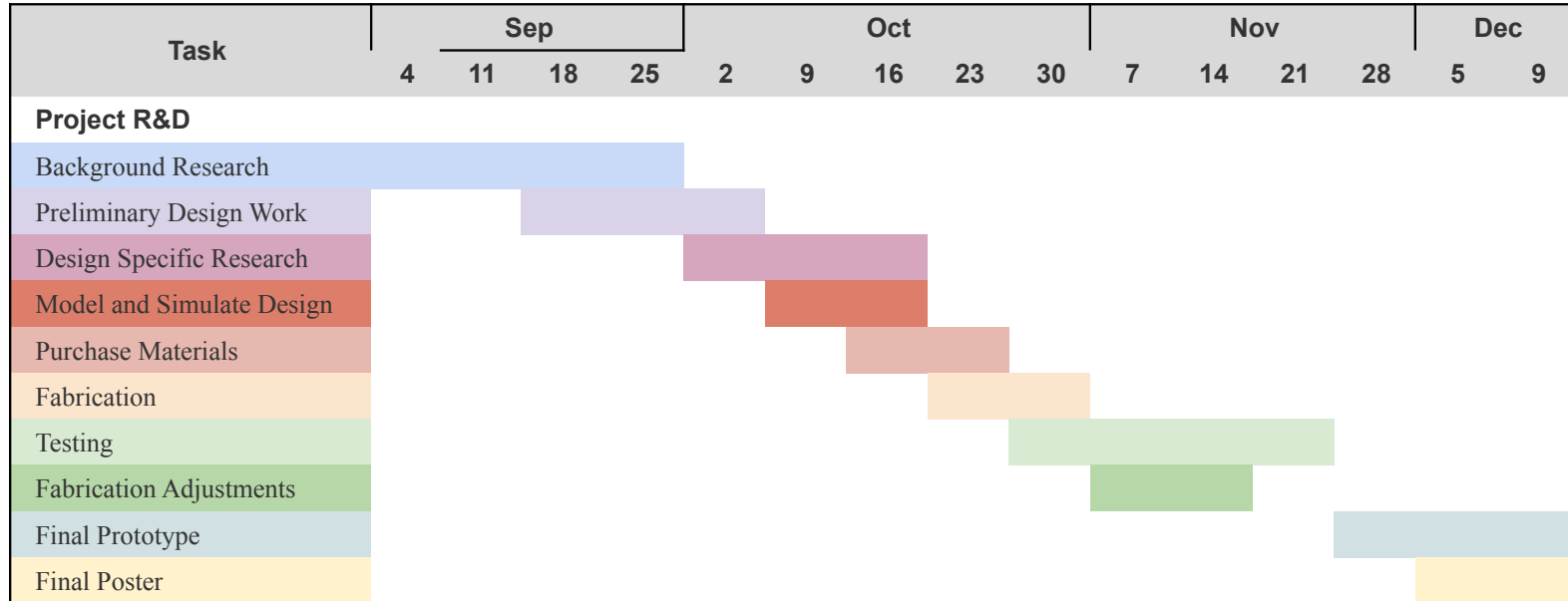


Figure 4: Gantt Chart

References and Acknowledgments

- [1] "Speaker Details," Wemsaexpo.com. Accessed: Sep. 30, 2026. [Online]. Available: <https://www.wemsaexpo.com/wemsa2026/speaker/2110545/lenard-markman-do>
- [2] J. K. Ayres and C. V. Maani, "Milrinone," PubMed, Aug. 28, 2023. [Online]. Available: <https://www.ncbi.nlm.nih.gov/books/NBK532943/> (accessed Sep. 11, 2026).
- [3] W. Akhtar et al., "Oral milrinone for management of refractory right ventricular failure in patients with left ventricular assist devices," *ESC Heart Fail.*, vol. 9, no. 6, pp. 4340–4343, Dec. 2022, doi: 10.1002/ehf2.14092.
- [4] "Milrinone infusion – management," South Eastern Health and Social Services Network (SCHN) Policy, Procedure and Guideline Committee, Cardiac Services, Clinical Practice Guideline 2010-0004 v4, Sep. 2023. Accessed: Oct. 1, 2026. [Online]. Available: <https://resources.schn.health.nsw.gov.au/policies/policies/pdf/2010-0004.pdf>
- [5] Cleveland Clinic, "IV fluids (intravenous fluids): Types & uses," Aug. 3, 2021. [Online]. Available: <https://my.clevelandclinic.org/health/treatments/21635-iv-fluids> (accessed Oct. 1, 2026).
- [6] Center, "Infusion pumps: Tips for using your pump at home," U.S. Food and Drug Administration, 2024. [Online]. Available: <https://www.fda.gov/medical-devices/infusion-pumps/infusion-pumps-tips-using-your-pump-home> (accessed Oct. 1, 2026).
- [7] A. A. Harhash et al., "Safety of outpatient milrinone infusion in end-stage heart failure: ICD-level data on atrial fibrillation and ventricular tachyarrhythmias," *Am. J. Med.*, vol. 133, no. 7, pp. 857–864, Jul. 2020, doi: 10.1016/j.amjmed.2019.11.023.
- [8] A. Author, "Inhaled vasodilatory agents for treatment of pulmonary hypertension in cardiac surgical patients," Ph.D. dissertation, Dept. of [Department], Univ. of Gothenburg, Gothenburg, Sweden, [Year]. [Online]. Available: <http://hdl.handle.net/2077/11491>
- [9] Hospira, Inc., "Milrinone lactate injection, solution," DailyMed, U.S. National Library of Medicine, Sep. 26, 2025. Accessed: Oct. 1, 2026. [Online]. Available: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=813e8ca2-de54-4a7c-a2d2-8bd44396c341>



Questions?

