

Continuous Remote Patient Monitoring: Evaluation of the Heart Failure Cascade Calibration And Test

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SUMMARY

Readmissions associated with Heart failure (HF) are a growing concern for healthcare systems. NorthShore University HealthSystem deployed a continuous remote patient monitoring (CRPM) program called Cascade HF to reduce the readmission rates. Results show out of 20 patients, there were only five readmissions from soft launch to the testing phase.

INTRODUCTION

- HF has a high rate of readmission, mortality, morbidity, reduced quality of life, and increased economic burden¹.
- Post-discharge remote monitoring has shown improvement in readmission rates².
- Machine learning techniques applied to physiologic data provides early indication of worsening HF and allows early intervention³.
- To reduce the HF readmission rates, a CRPM program, Cascade HF, was deployed at Evanston Hospital (Evanston, IL) with a structured workflow involving entire clinical team (figure 1)⁴.
- The primary goal of this study is to reduce 30-day readmissions and determine feasibility of the CRPM.
- Preliminary data supporting feasibility was gathered, analyzed and reported for the first 20 participants.

METHOD

- CASADE HF is a 3-phase, prospective, non-randomized study started Dec 2020 and is ongoing.
- HF patients were enrolled and managed 30-days post discharge using a CRPM solution, continuous physiologic data was streamed from chest worn non-invasive biosensors and analyzed by machine learning algorithms.
- Notifications of physiological perturbation were generated, and patient-reported outcome responses were displayed on web-based portal and reviewed daily.
- Personalized alerts included tachypnea, tachycardia, Afib with RVR, and an alert that recognizes when the person's physiology is changing compared to their baseline physiology, called the multi-variate change index (MCI alert).
- If a notification was displayed, the HHN escalates to HF team for further evaluation and early intervention (table 1).

Table 1: Heart Failure Monitoring Workflow

HF Monitoring Workflow		
Alerts	Example/Definitions	Clinical Team
Yellow zone symptoms	SOB, orthopnea, LE edema or weight gain \geq 5 lbs	HHN contact patient, assess, route note to clinical team → APP's escalate oral diuretics
Multi-Variate Change Index (MCI)	A change in patient's physiological pattern relative to the learnt baseline, identifying early signs of worsening symptoms	HHN contact patient, assess, route note to clinical team → Perform assessment, Draw labs (CBC, CMP, ProBNP), escalate oral diuretics
Rule based alerts	Tachypnea, tachycardia, bradycardia, Afib, Afib w/RVR	HHN contact patient, assess, route note to clinical team → Perform assessment, consider labs, and escalate oral diuretics
Red zone	Unrelieved SOB, chest pain, chest tightness, confusion, anxiety	HHN contact patient, assess, send to ED → Call MD or send patient to ED

Table 1 Abbreviations: SOB: Shortness of Breath; LE Edema: Lower Extremity Edema; MCI: Multi-Variate Change Index; Afib: Atrial Fibrillation; RVR: Rapid Ventricular Rate; HHN: Home Health Nurse; ED: Emergency Department; MD: Doctor of Medicine; APP: Advance Practice Providers; CBC: Complete Blood Count; CMP: Comprehensive Metabolic Panel; ProBNP: Pro-B-type Natriuretic Peptide

Figure 1: Heart Failure Monitoring Workflow



Table 2: Results-Alert Metrics

Study period	Soft Launch					Calibration Period					Testing Period									
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Total Number of Clinical Alerts	7	34	62	23	2	39	9	0	37	78	2	6	0	0	1	1	1	0	0	0
Number of MCI alerts	0	1	1	1	0	0	4	0	0	4	2	6	0	0	1	1	0	0	0	0
Number of tachypnea alerts	0	33	61	22	2	0	5	0	0	68	0	0	0	0	0	0	0	0	0	0
Number of other alerts	7	0	0	0	0	39	0	0	37	0	0	0	0	0	0	0	0	0	0	0
30-day Readmission	No	Yes	Yes	No	W	No	No	No	No	No	No	Yes	S	No	No	Yes	Yes	W	No	No

RESULTS

- Of the 20 patients enrolled in this study, five readmitted (2 HF-related and 3 non HF-related), two patients withdrew due to non-adherence to study procedures.
- All patients were at or above New York Heart Association (NYHA) function class II
- Subject 102 had multiple tachypnea alerts which eventually led to an MCI alert and was readmitted the same day of diuretics escalation
- Subject 104 had multiple tachypnea alerts and an MCI alert. HHN assessed him and they noticed that patient was non-adherent with diuretics.
- Subject 110 had frequent tachypnea alerts that led to assessment and diuretic escalation
- **Place holder for QR code for case study**

CONCLUSION

- CRPM has shown significant improvement in readmission rates
- Workflows and escalation pathways are helpful in guiding care.
- Combination of MCI alerts and rule-based alerts for monitoring are beneficial.
- Dedicated nursing staff for monitoring alerts and patient surveys is necessary for implementation.
- Multi-level support is needed throughout monitoring process: Nursing, Advanced Practice Providers (APPs), and Physicians.
- Multi-disciplinary approach including research, recruitment, monitoring, management, and treatment is required.
- Essential to have all communication through the same Electronic Medical Record (EMR) to streamline communication and access to patient information.

RECOMMENDATIONS

- Administration support is necessary to ensure adequate home health nursing staff is available, as well as modifying APP schedules and availability is needed to call and follow up with patients in real time.
- Continuous education and training in remote monitoring would be beneficial in future to execute remote monitoring activities and workflows.

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