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VPExam in Heart Failure Innovating Virtual Cardiac Care

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Abstract

Telehealth and Virtual care are growing fields of importance, but the loss of comprehensive physical exam creates barriers to managing complex patients especially those with heart failure. Disruptive digital tools such as VPExam virtual care combine augmented reality instruction of visuals with bluetooth stethoscopes and ECGs to improve accuracy by assessing volume status, cardiopulmonary auscultation, arrythmia detection, and providing structured data including remote patient monitoring (RPM) data, vitals, medication reconciliation, and labs. VPExam intervention has significantly improved outcomes for high-risk and underserved populations with heart failure discharged to Skilled Nursing Facilities and Home Care. VPExam QI revealed workflows for both routine and urgent cardiology consultation following heart failure hospitalizations resulted in moderate significance modification in clinical management in 84% of encounters, while being associated with a 40% relative risk reduction in 30-day hospital readmission rate and a 56% relative risk reduction in 30-day mortality rate. The review summarizes both challenges to cardiac transitions of care and the evolution of cardiac virtual care with actionable physical exam data to optimize readmissions and mortality that is especially relevant to the underserved populations of skilled nursing facilities and home bound patients served by home care agencies.

Keywords: Telemedicine, Quality Improvement, Remote Patient Monitoring (RPM), Transition of care, Physical exam.

Introduction

Heart failure (HF) is a leading cause of morbidity and mortality in 5.7 million Americans. Management costs predicted to reach 70 billion dollars by 2030 (Ponikowski et al., 2016). Skilled nursing facilities (SNFs) care for older patients with significant comorbidities (Orr et al., 2015). Morbidity and mortality rates are high for hospitalized heart failure patients discharged to SNFs with 30-day readmission rates between 27 to 43% due to errors in transitions, inadequate discharge planning, and lack of appropriate follow-up with health care providers (Jurgens et al., 2015). There is increasing focus on digital health as a potential disruptive of intervention that can support healthcare providers in decision making as well as interprofessional communication, while providing the necessary training to improve overall healthcare to improve the sustainability and efficacy of interventions in SNFs (Fatehi et al., 2020). Optimizing HF management in SNF populations is also a focus of value-based care.

Numerous analyses have demonstrated that compared to conventional care, the addition of telemedicine in heart failure management leads to reduced hospitalization and mortality (Zhu et al., 2020; Gingele et al., 2019). Traditional telemedicine presents obstacles including affordability of equipment, difficult to use technology requiring extensive training, lack of standardization, and patient privacy issues. These types of barriers are especially challenging to SNF and Home Care populations with significant comorbidities, functional impairments, and barriers to transportation (Woo & Dowding, 2018). Virtual care can offer these populations improved access, but this is typically at the expense of clinical data such as a comprehensive physical examination. Most common and clinically expensive cardio-pulmonary diseases rely on the physical examination for detection of decompensation or exacerbation. Lack of physical exam data results in loss of early detection of clinical decompensation, reduced clinical confidence, and increased risk of misdiagnosis.

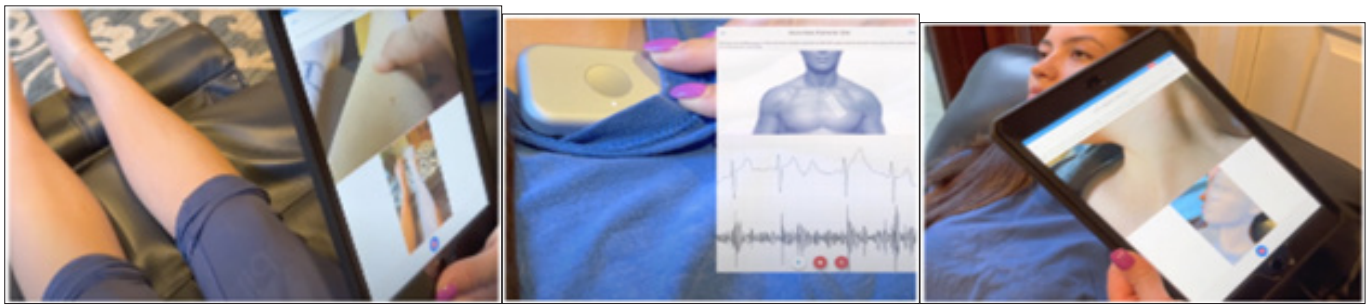
VPExam Overview

VPExam is a Health Insurance Portability and Accountability Act (HIPAA) compliant medical device data system that overcomes barriers of traditional telemedicine utilizing a combination of asynchronous and synchronous virtual care utilizing augmented reality (AR) based training leading a minimally trained technician including nurses, medical assistants, patients, and their family members through appropriate camera positioning for video capture of anatomical

landmarks. VPExam augmented reality guided overlays combined with sample videos and customized assessment instructions teach users to obtain optimal video recordings of clinical findings of jugular venous distention and lower extremity edema in an efficient and highly reproducible manner.

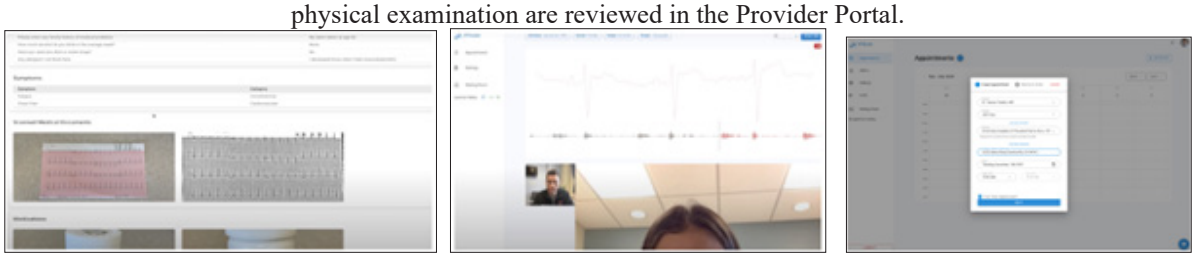
VPExam is integrated with Bluetooth enabled stethoscopes with integrated ECG to capture a full heart and lung exam with active user instruction (Figure 1). VPExam also known as virtual physical examination components are customizable by providers and specialty to optimize an efficient clinical workflow.

Figure 1: VPExam Clinical App. Augmented reality guidance with Bluetooth enabled stethoscope allows a minimally trained user to capture key physical exam data. Informed consent was obtained for the publication of any potentially identifiable images or data included in this article.



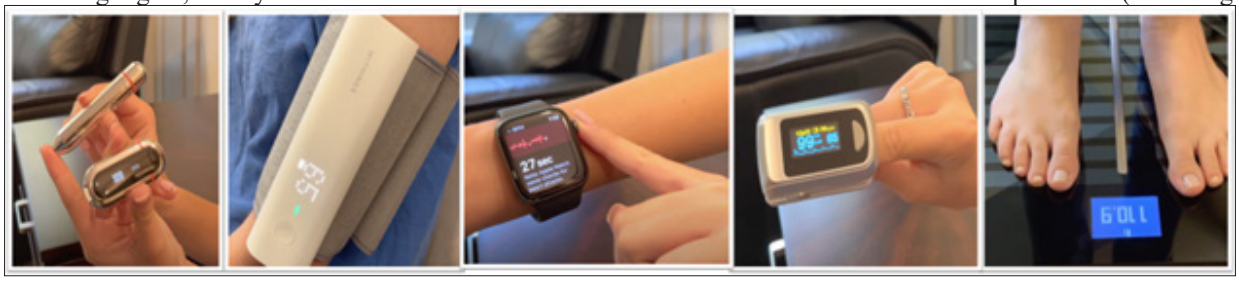
Time efficient review of asynchronous patient management data is critical for physician engagement. VPExam allows nurses to transmit structured data including vitals, voice recognition virtual history and review of systems, medication reconciliation with photographs of pill bottles, a document scanner to transmit laboratory results, orders, logs, ECGs, etc. (Figure 2). Providers review the VPExam Physician Portal asynchronous data prior to initiating a real time HIPAA compliant video conference with the patient. The Bluetooth stethoscope with ECG can also be used by the provider during real time synchronous video conferencing in coordination with the nurse/ Medical Assistant (MA) user with the patient (Figure 2). VPExam transmits digital physical exam data for comprehensive assessment of volume status, cardiopulmonary auscultation, ECG detection of arrythmias, and structured data.

Figure 2: VPExam Provider/ Partner Portal. Virtual history, review of systems, medications, document scanner, and virtual physical examination are reviewed in the Provider Portal.



VPExam also offers additional Remote Patient Monitoring (RPM) utilizing Apple Health and Google Fit data transmission to the VPExam Provider Portal including blood glucose, body mass index, cardio fitness, blood pressure, electrocardiogram, heart rate, oxygen saturation, walking heart rate, and weight (Figure 3). VPExam allows for transmitting urgent data including tachycardia with arrythmia from a smart watch revealing a patient going into atrial fibrillation or greater than three-pound weight gain from a Bluetooth scale revealing a patient suffering from decompensation of heart failure. Abnormal RPM data can trigger deployment of personnel to perform VPExam in patients' home or facility for earlier physician intervention.

Figure 3: VPExam Remote Patient Monitoring (RPM). Smart watch data including ECG, heart rate, pulse ox as well as blood pressure, blood glucose, scale data are transmitted (upper Figure). RPM can alert providers to uncontrolled hypertension, significant weight gain, or arrythmias via the VPExam Provider Portal for earlier detection of decompensation (lower Figure).



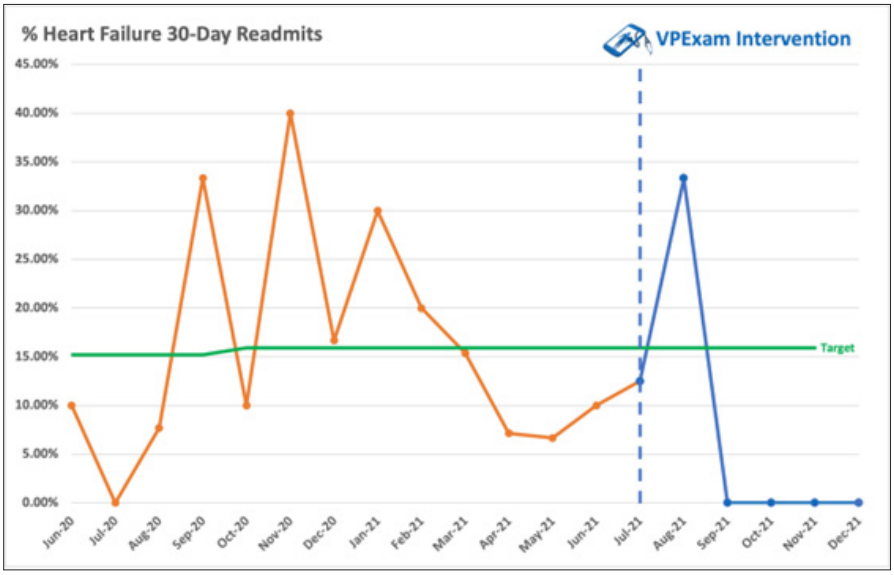
Takeaways from VPExam QI

VPExam Virtual Care for Heart Failure Optimizing Transitions of Care Quality Improvement Project (VPExam QI) was a single-arm prospective comparative case study recruiting patients admitted for heart failure with anticipated discharge to SNFs or Home Care (Woo & Dowding, 2018). Nursing satisfaction was 4.8/5 (± 0.22) with 0% technical errors at three SNFs and deployment on over 550 Home Care devices. VPExam QI patients received clinical follow up for approximately 2-3 weeks duration. Data collection occurred for 3 months following initial VPExam encounter. There were no patients who declined participation and there were no dropouts. 19% of study encounters occurred with Home Care services, while 81% of encounters occurred at Skilled Nursing Facilities. During the 6-month pilot, 33.8% of all hospitalized heart failure patients at University Hospitals of Cleveland Regional Hospitals were enrolled into VPExam QI with cardiology management based on guideline directed therapy.

84% of VPExam encounters required moderate significance changes in clinical modification. The most common changes involved diuretic adjustments in 44% of encounters with vasoactive medication adjustments in 44% of encounters. Less frequent moderate significance clinical modifications included identification of medication reconciliation errors in 8% of encounters with alteration of antiarrhythmic medications in 4% of encounters. Moderate significance modification encounters were impacted by volume status assessment (47.6%), cardiopulmonary auscultation (33.3%), ECG detection of arrythmias (14.2%), and structured data transmission of vitals, medication reconciliation, and lab results (95.2%).

The historic control population hospitalized with a primary diagnosis of heart failure from June 2020 to June 2021 had an average monthly all cause readmission rate of 15.91%. Intervention with VPExam QI was correlated to a 30-day hospital readmission rates reduction to 7.98% with a 40.1% relative risk reduction. In the final 3,4,5, and 6 month periods of VPExam QI, readmission rates fell precipitously to 0% (Figure 4).

Figure 4: Hospital readmission rates before and after VPExam QI intervention. Hospital readmission data averages a monthly 30-day readmission rate of 15.91% for the year leading up to VPExam QI. During the initial 6 months of VPExam QI, the average monthly 30-day readmission rate for all University Hospital of Cleveland Regional Hospitals fell to 7.98% with 0% readmissions found for the last 4 consecutive months of VPExam QI.



Across all heart failure subtypes, the mortality rate following hospitalization are historically approximately 10.4% at 30 days, 22% at 1 year, and 42.3% at 5 years (Shah et al., 2022). 30-day mortality in VPExam QI was significantly lower with a 30 days mortality rate calculated at 4.54% with a relative risk reduction of 56.3 % compared to historical controls.

Discussion

Virtual Care Barriers

Significant barriers to routine telemedicine intervention in literature review include:

1. The HF presentation can be non-specific making diagnose difficult.
2. Guideline-directed drugs are underused for many reasons including concerns for their utility and safety.
3. SNF providers who are typically not specialists or Cardiologists are uncomfortable managing HF due to complexity and autonomy at end-of-life decisions.
4. There is mistrust and lack of timely communication between staff, physicians, patients, and their families.
5. There are limited resources in terms of diagnostic studies as well as access to specialists for care.
6. There is poor transfer capabilities. (Orr et al., 2015; Woo & Dowding, 2018; Joseph et al., 2020; Heckman et al., 2020).

VPExam QI reveals unique virtual care software and workflows overcome many of these barriers while creating a successful local Virtual Care Network (VCN). VCNs connect hospital systems and partner with Post Acute Care Quality

Networks to high functioning SNFs and Home care agencies. VPExam deployment to SNFs and Home Care agencies is in both the patient and physicians' best interest while remaining feasible, scalable, and cost effective. VPExam VCNs enable high compliance with follow-up with high satisfaction from nursing staff.

Structured data transmission of vitals improved detection of uncontrolled hypertension, hypotensive episodes, and tachyarrhythmias often missed in traditional telemedicine. Structured data transmission of medication reconciliation often identified high risk errors. Structured data transmission of labs including renal function, brain natriuretic peptide (BNP) trends, and blood count stability improved the quality and competence of medical decision making.

VPExam is also suited to improve clinical decisions with unique physical exam data as volume status including jugular venous distention and lower extremity edema influenced moderate modification management in about 50% of encounters. Synchronous and asynchronous stethoscope auscultation of the heart to detect murmurs, rubs, gallops, irregularity, as well as auscultation of the lungs to detect wheezing and rhonchi influenced moderate modification management over 31% of encounters. Synchronous and asynchronous ECG transmission for arrythmia detection including atrial fibrillation influenced moderate modification management in over 13.6% of encounters.

As always, there are financial considerations for various stakeholders. Transfer from skilled nursing facilities' (SNF) to emergency departments are linked to increased morbidity and mortality as well as significant cost (Benjamin et al., 2017). The average cost of readmission is $15,200 across various payers, yet there are over 233,100 readmissions for heart failure, 81,600 readmissions for cardiac arrythmias, and 74,300 readmissions following myocardial infarct annually. Other high-risk conditions benefitting from VPExam workflows for cardiopulmonary and volume status evaluation include COPD with 106,300 readmissions, pneumonia with 7,500 readmissions, and renal failure with 96,900 readmissions annually (Heckman et al., 2020).

Conclusion

Virtual Care Feasibility

VPExam QI results demonstrate that virtual transitional care for SNFs and Home Care agencies offer a large opportunity to improve quality of care, while mitigating risk of errors for high risk underserved patients. The reduction in 30-day hospitalization and mortality further empowers care providers to optimize this type of disruptive transitional care technology. VPExam helps reduce the cost of transporting patients to specialists and hospitals including ambulance and nursing expenses. Virtual care also helps reduce the risk of contracting infectious diseases during health care visits. In addition to the financial incentivization of virtual care mitigating the cost of readmissions, the platform simultaneously increases individual provider productivity via pathways for

1. higher complexity clinical encounters;
2. Remote patient monitoring (RPM);
3. Transitional Care Management (TCM) and Chronic Care Management (CCM).

Virtual care offers earlier detection of clinical decompensation to underserved communities and better decisions by clinicians with reduced risk of hospital admission and mortality on discharge. Improved transitional care assists health care systems in preventable penalties, unnecessary care escalation, and more efficient utilization of limited inpatient and ICU beds.

Transitional Outlook of Virtual Care

Implementing virtual care to improve transitions of care in the underserved SNF and Home Care patient populations represents a promising measure to intervene on readmission rates for high-risk HF populations. VPExam offers capabilities to transmit virtual physical exam cardio-pulmonary and volume status assessments with supplemental structured critical to competent provider clinical decision making for real world heart failure management. Noninvasive virtual care platforms offer novel interventions to reduce readmission and mortality rates, while improving patient and physician satisfaction. Future projects should focus addressing the paradigm of cost-effective health care delivery given the growing challenges of increasingly scarce health care resources. Ongoing government and hospital support for digital innovation research allow physicians the opportunity to define the workflows to optimize efficiency and quality of care.

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