Original Research Article

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Reducing rates of readmission and development of an outpatient management plan in pulmonary hypertension: lessons from congestive heart failure management

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Abstract

Pulmonary hypertension currently has minimal guidelines for outpatient disease management. Congestive heart failure studies, however, have shown effectiveness of disease management plans in reducing all-cause mortality and all-cause and congestive heart failure-related hospital readmissions. Heart failure exacerbation is a common reason for readmission in both pulmonary hypertension and congestive heart failure. Our aim was to review individual studies and comprehensive meta-analyses to identify effective congestive heart failure interventions that can be used to develop similar disease management plans for pulmonary hypertension. A comprehensive literature review from 1993 to 2019 included original articles, systematic reviews, and meta-analyses. We reviewed topics of outpatient congestive heart failure interventions to decrease congestive heart failure mortality and readmission and patient management strategies in congestive heart failure. The most studied interventions included case management, multidisciplinary intervention, structured telephone strategy, and tele-monitoring. Case management showed decreased all-cause mortality at 12 months, all-cause readmission at 12 months, and congestive heart failure readmission at 6 and 12 months. Multidisciplinary intervention resulted in decreased all-cause readmission and congestive heart failure readmission. There was some discrepancy on effectiveness of tele-monitoring programs in individual studies; however, meta-analyses suggest tele-monitoring provided reduced all-cause mortality and risk of congestive heart failure hospitalization. Structured telephone strategy had similar results to tele-monitoring including decreased risk of congestive heart failure hospitalization, without effect on mortality. Extrapolating from congestive heart failure data, it seems strategies to improve the health of pulmonary hypertension patients and development of comprehensive care programs should include structured telephone strategy and/or tele-monitoring, case management strategies, and multidisciplinary interventions.

Keywords

pulmonary hypertension, pulmonary arterial hypertension, pulmonary circulation, pulmonary heart disease

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Pulmonary hypertension (PH) is a progressive group of diseases that remains difficult to treat and carries significant morbidity and mortality despite available medical therapy. Currently, there are minimal guidelines on chronic outpatient management and prevention of hospitalization owing to the low number of patients and orphan status of the disease. In contrast, numerous studies and reviews in congestive heart failure (CHF) including the Cochrane review have shown effectiveness of disease management plans in reducing key endpoints including all-cause mortality, heat failure admissions, and all-cause and CHF-related hospital readmissions. A key similarity between PH and CHF is heart failure exacerbations which is a significant and

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common reason for readmission. Due to physiologic similarities, fluid management and patient compliance challenges, and the chronic nature of these two diseases, we believe applying similar disease management strategies in PH could be of patient benefit.

Methods

A comprehensive literature review was conducted utilizing original articles, meta-analyses, and systematic reviews from 1993 to 2019. We examined the interventions identified in the Cochrane review[1–3] and limited our analysis to larger studies with these methodologies. Articles reviewed specifically included these outpatient CHF interventions and their effect on one or more of the following: all-cause admission or readmission, CHF admission or readmission, and all-cause or CHF mortality. Primary endpoints of our review were all-cause mortality, CHF hospitalization and readmission, and all-cause hospitalization and readmission. We included in our data analysis statistically significant studies that also provided a description of intervention(s) used, documentation of outcomes, and study population size greater than or equal to 150 persons. Articles were excluded if a specific diagnosis of CHF was not listed and if primary endpoints of interest did not reach statistical significance or were not reported.

Data collection

Literature search was performed using the following keywords: heart failure, readmission, admission, telemonitoring, telecommunication, telemedicine, structured telephone support, structured telephone system, case management, and multidisciplinary. Referenced studies were searched as well. Review of individual articles and meta-analyses focused on study power, intervention, and primary and secondary outcomes.

Results

A total of 76 original trials, meta-analysis, and reviews were identified. Of these, 17 met our inclusion criteria, comprising 7681 patients. Each of the 17 studies showed statistically significant results favoring intervention for at least one primary endpoint. There were no statistically significant studies during our review that favored usual care over specified interventions.

We were able to identify four primary categories of interventions consistent with those in the Cochrane review. Case management (CM), which was specialist nurse driven, included education pre/postdischarge, specialist nurse home visits, scheduled telephone calls for symptom management, and teaching for when to seek help.[4–7] Multidisciplinary intervention (MI), which was also specialist nurse driven, was comprised of coordinated interventions and communications including patient–caregiver education regarding their disease, medication and diet, nurse clinic visits, regular telephone calls, individualized follow-up plan, and access to physician, nurse, dietician, pharmacist, and social worker.[8–16]

Remote monitoring programs consisted of structured telephone strategy (STS) which involved monitoring collected data via human–human or human–machine interactive response system.[1,5,17–20] Lastly, tele-monitoring (TM) which comprised of physiologic data transmission of electrocardiogram (EKG), blood pressure, weight, respiratory rate digitally.[1,5,7,16,17,19,21–33]

CM showed decreased all-cause mortality (ACM) at 12 months, all-cause readmission (ACR) at 12 months, and CHF readmission at 6 and 12 months. MI resulted in decreased ACR and CHF readmission (Table 1). There was some discrepancy on effectiveness of TM programs alone in individual studies; however, large meta-analysis suggests TM provided a reduction in ACM and risk of CHF hospitalization and was a common factor of successful management plans. STS had similar results to TM including decreased risk of CHF hospitalization and ACM (Table 2).

Cochrane's review identified a reduction in ACM and heart failure admissions with STS and TM. In addition, CM probably reduced heart failure readmissions and all-cause readmissions, while MI may have reduced heart failure readmissions and all-cause readmissions. There was some evidence that CM and MI may reduce ACM.

Even though the above conclusions were found, no specific recommendations have been developed to guide implementation of these interventions.

CM versus MI

The primary difference between CM and MI is coordination of care. Although both models focus on providing individualized patient care, MI encourages providers from multiple specialties to liaise with one another with the purpose of optimizing the efficiency and quality of patient–provider and provider–provider visits. Providers have direct communication with one another through either contemporaneous multidisciplinary visits with patients or individual visits which are reported and reviewed by a centralized specialist physician and/or nursing in charge of coordinating care. MI also expanded the patient management team to include social workers, dieticians, and pharmacists. CM had similar management, and intervention components, however, did not employ multidisciplinary patient visits. Specialist physician and nursing were typically in charge of coordinating additional care, generating referrals, and follow-up visits in conjunction with the patient's primary care physician.

Implantable hemodynamic monitors

An interesting and upcoming technology from CHF trials are implantable hemodynamic monitors (IHMs). Initially investigated in several CHF studies comprised of patients

Table 1. Statistically significant Case Management and Multidisciplinary Intervention studies.

CM–MI	Study	Number of patients	Intervention	Outcome
	Atienza et al.[4]	338	CM: Specialist clinic, education, TM, individual patient plan Persons involved: Cardiologist, cardiac nurse, general practitioner, other specialists as required	ACM: reduced (RR 0.62) ACR: reduced (RR 0.71) HFR: reduced (RR 0.52)
	Rich et al.[14]	282	MI: Nurse-driven education, home visit, pharmacist visit, 7 days postdischarge Persons involved: Cardiologist, cardiac nurse, pharmacist, social services, dietician	HFR: reduced (RR 0.44) ACR: reduced (RR 0.56)
	Naylor et al.[13]	239	MI: Nurse driven, specialist clinic, training program, case management Persons involved: Cardiologist, cardiac nurse, pharmacist, nutritionist, social worker, physical therapist	ACR: reduced (RR 0.77)
	Capomolla et al.[9]	234	MI: Multidisciplinary heart failure clinic with regular telephone contact Persons involved: Cardiologist, cardiac nurse, physiotherapist, dietician, psychologist, social assistant	ACR: reduced (RR 0.32)
	Ducharme et al.[10]	230	MI: Specialty clinic, 1-1 education, risk factor modification, TM, diet Persons involved: Cardiologist, clinician nurses, dietician, pharmacist, social worker, other specialists as required	ACR: reduced (RR 0.77)
	Del Sindaco et al.[6]	173	MI: Specialty clinic, discharge planning, education, intensive follow-up, phone calls, home visits by primary care physician Persons involved: Cardiologist, cardiac nurse, general practitioner	ACM: reduced (RR 0.85) HFR: reduced (RR 0.58)
	Blue et al.[8]	165	MI: Specialty nurse-driven education, initial in hospital visit. Home visit and telephone contact as needed. Psychological support, protocol-driven medication titration Persons involved: Cardiologist, cardiac nurse	HFR: reduced (RR 0.44)

CM: case management; MI: multidisciplinary intervention; TM: tele-monitoring; ACM: all-cause mortality; HFR: heart failure readmission; ACR: all-cause readmission; RR: relative risk.

ranging from New York Heart Association (NYHA) class II–IV, these devices have been met with mixed results primarily based on potential study bias, blinding, and protocol-guided therapy challenges. The CardioMEMS Heart Sensor Allows Monitoring of Pressure to Improve Outcomes in NYHA Class III Heart Failure Patients (CHAMPION) trial study,[34,35] however, showed statistically significant reductions in CHF-related hospitalizations (hazard ratio (HR) 0.72, 95% confidence interval (CI) 0.60–0.85, $p = 0.0002$) and led to food and drug administration approval of the CardioMEMS implant for management of heart failure. Conversely, the Diagnostic Outcome Trial in Heart Failure (DOT-HF) trial[36] showed a trend toward higher risk of primary endpoint (ACM or hospitalization for CHF) (HR 1.52, 95% CI 0.97–2.37, log-rank $p = 0.063$) compared to the control group. This was due to

Table 2. Statistically significant Structured Telephone Strategy and Tele-Monitoring studies

STS–TM	Study	Number of patients	Intervention	Outcome
	Koehler et al.[29]	1571	TM+STS: daily weight, blood pressure, heart rate, EKG, oxygen saturation, self-rated health status via tele-monitoring system. Education via structured phone	ACM: reduced (HR 0.70)
	GESICA Investigators[18]	1518	STS: Education, counseling, and monitoring	HFA: reduced(RR 0.71) ACH: reduced (RR 0.85) HFM: unchanged
	Angermann et al.[21]	708	STS: Education and monitoring	ACM: reduced (HR 0.62)
	Kielblock et al.[28]	502	TM: Weight monitoring, designated personal advisor	HFM: reduced (RR 0.54)
	Giordano et al.[25]	460	TM: Every 1–2 weeks scheduled tele-appointment. Self-measurement of weight, blood pressure, medication compliance. EKG transmission. Education: diet, signs, and symptoms	ACR: reduced (RR 0.50) HFR: reduced (RR 0.49)
	Riegel et al.[20]	358	STS: Telephone call 5 days postdischarge. Frequency then based on symptoms, knowledge, and needs	HFA: reduced (RR 0.55)
	Goldberg et al.[26]	280	TM: Daily weight and symptom monitoring	ACM: reduced (RR 0.44)
	Cleland et al.[22]	258	TM: Home tele-monitoring (twice daily weight, blood pressure, heart rate, EKG) or nurse telephone support (monthly telephone calls, assess symptoms, and medication) STS: Twice daily patient self-measurement of weight, blood pressure, heart rate, and rhythm	ACM: reduced. TM (RR 0.73) and STS (RR 0.68)
	Merchant et al.[31]	205	TM: Internet-based monitoring: blood pressure, weight, symptoms. Included predischarge nurse practitioner-driven education	ACR: reduced (RR 0.59) HFR: unchanged
	Dendale et al.[23]	160	TM: Daily monitoring of weight, blood pressure, heart rate	ACM: reduced (5% vs. 17.5%)

STS: structured telephone strategy; TM: tele-monitoring; EKG: electrocardiogram; HFA: heart failure admission; ACM: all-cause mortality; HFM: heart failure mortality; HFR: heart failure readmission; ACR: all-cause readmission; ACH: all-cause hospitalization; RR: relative risk; HR: hazard ratio.

an increase in unplanned hospitalizations for HF (HR 1.79, 95% CI 1.08–2.95, $p = 0.022$).

Raina et al.[37] performed a retrospective analysis of the CHAMPION trial data and found improved risk stratification of patients with the use of IHM in addition to right heart catheterization (RHC). Those patients with no PH on RHC or IHM had lower HF hospitalization rates than those patients with no PH on RHC but did have PH on IHM (0.25 vs. 0.49, Incidence Rate Ratio (IRR) 0.51, 95% CI 0.33–0.77, $p = 0.0007$). No mortality difference was seen.

All positive interventions are listed in Tables 1 and 2.

Examples of strategies of each type of intervention that showed positive outcomes are listed below.

Structured telephone strategy

GESICA Investigators[18] employed a strategy consisting of specialist nurse-led education, counseling, and monitoring through frequent telephone follow-up in addition to usual care. Patients were treated by their attending cardiologist and follow-up at least every three months. Nurses trained specifically in heart failure performed telephone follow-ups. Telephone calls were initiated within seven days of discharge. The purpose of telephone calls was to educate and monitor the patient. Data included adherence to diet, drug treatment, monitoring of symptoms (particular attention to disease progression, i.e. dyspnea, edema), control of signs of fluid retention, and daily physical activity. Predetermined

questionnaires were provided for nurses along with standardized intervention procedures. Nurses were able to adjust the dose of diuretics and also determine if nonscheduled or emergent medical attention was needed. The outcome of this intervention strategy was a significant reduction in CHF and all-cause hospital admissions.

Tele-monitoring

Giordano et al.[25] developed a TM strategy with two specialty nurse-driven procedures. The first consisted of scheduled weekly TM appointments (TM). A standardized interview includes evaluation of patient's diet (fluid management, weight monitoring, salt intake, and smoking habits), weight, blood pressure, medication knowledge and compliance, and EKG. At future appointments, nursing reinforced education and patient compliance strategies. The second procedure consisted of occasional appointments (tele-assistance), escalated from TM. This was done if the patient was experiencing signs or symptoms of decompensation or had a concern about therapeutic plan. Further intervention included drug modification (predetermined or nurse contacting specialist physician or primary care physician) or new scheduled appointment. Nursing was required to consult the physician to determine if emergency room or additional specialist clinic follow-up was required. This intervention strategy was successful and resulted in significant reduction in all-cause and heart failure readmissions.

Case management

Atienza et al.[4] created a three-phase CM program. The first phase was disease education for patients and families. Before discharge, a specialist nurse interviewed patient and family to determine disease knowledge base, ability to identify signs and symptoms of disease worsening, and how to respond to deterioration. Education included importance of self-monitoring, diet and exercise, signs and symptoms of heart failure, and medication compliance. The second phase included a primary care physician visit within 2 weeks of discharge. During visit, the patient's clinical progress was assessed to determine risk of deterioration. If deterioration was anticipated, medication modification was performed, and primary care had the option to refer to hospital for reassessment. The third phase included specialist clinic follow-up visits every three months for routine clinical assessment, where patient performance was analyzed and strategies to improve treatment adherence employed. In addition, reinforcement of disease knowledge and self-management, referral to other specialist, diagnostic tests, and treatments if needed was performed. The end of the study concluded with telephone communication. This leads to a significant reduction in ACM, heart failure admissions, and ACRs.

Multidisciplinary intervention

Rich et al.[14,15] chose an MI model. This included intensive disease education by experienced specialist nurse using teaching booklets, individual diet assessment, and instructions given by a registered dietician, social services evaluation to facilitate discharge planning and posthospitalization care, and medication analysis by specialist physician focusing on eliminating unnecessary medications and regimen simplification. Individualized education included specialist nurse-led daily visits while hospitalized addressing diagnosis, symptoms, treatment, follow-up and prognosis. Emphasis placed on importance of self-monitoring and instructions of when to call should monitoring parameters exceed limits provided. An intensive discharge follow-up schedule was created via the hospital's home care services which were supplemented with nursing home visits and telephone contacts with study team members. First follow-up home visit occurred within 48 h of hospital discharge. Home environment assessment, additional education and teaching materials, and activity guidelines were addressed by the home-care nurse. Three visits were performed during week 1 postdischarge. Routinely scheduled nursing telephone calls were done to assess patient progress and address questions or concerns. Similar to prior intervention strategies, the goals of follow-up were education reinforcement, medication and diet compliance, and identifying symptoms amenable to outpatient treatment. This management plan leads to a reduction in heart failure admission rates.

Stewart et al.[38] discussed in excellent detail the components of a multidisciplinary PH center including its members, their functional roles, work flow of patients from diagnosis to treatment, as well as the importance of patient education and empowerment.

Implantable hemodynamic monitors

Benza et al.[39] performed IHM implantation in 14 pulmonary arterial hypertension (PAH) patients with NYHA class III/IV symptoms and recent hospitalization for heart failure. Mean duration of follow-up was 14 months. They found statistically significant hemodynamic improvements in mean pulmonary artery pressure, total pulmonary resistance, cardiac output, and stroke volume. In addition, brain natriuretic peptide (BNP) levels <340 pg/ml were maintained or achieved in 75% of patients after one month, patient functional class improved, and annual CHF hospitalization was decreased. Of note, there were no reported periprocedural complications or device-related serious adverse events postimplantation. This data suggest that IHM may be a safe adjunct therapy in PAH patients to reduce hospitalizations, improve functional status, and facilitate optimization of hemodynamics (Table 3).

Table 3. Implantable Hemodynamic Monitor studies

IHM	Study	Number of patients	Intervention	Outcome
	Hindricks et al.[27]	716	ICD or CRT-D equipped with Biotronik home monitoring function in NYHA class II or III	HFM: reduced (HR 0.37)
	Abraham et al.[34]	550	Implantable hemodynamic monitor in NYHA class III heart failure	HFR: reduced (HR 0.72)
	Benza et al.[39]	14	CardioMEMS IHM device implantation in PAH: Nonprotocol-based disease management	HFR/patient year: reduced (CI 0.182–0.934)

IHM: implantable hemodynamic monitor; HFM: heart failure mortality; HFR: heart failure readmission; HR: hazard ratio; CI: confidence interval; ICD: implantable cardioverter defibrillator; CRT-D: cardiac resynchronization therapy with a defibrillator device; NYHA: New York Heart Association; PAH: pulmonary arterial hypertension.

Table 4. Summary of comprehensive care plan components

Comprehensive care plan (CCP) intervention recommendations for Pulmonary Hypertension Clinics
Recommend combination intervention of below therapies
Possible exception of adding CM to TM—did not show benefit in one study[25]
Optimal intervention strategy may be resource, medical center, and provider dependent.

Intervention	Components of intervention	Purpose/timing
Predischarge education	-Nurse-led disease, medication, diet, symptom management, treatment education for patient and family -Reviewed potential adverse medication effects and indications of when to contact study personnel -Variations of brochures, diaries and teaching booklets provided	-Performed daily while inpatient -Stressed importance of self-monitoring and patient empowerment to manage disease process (i.e. medication titration) and when to seek help
Postdischarge specialty nurse telephone call (STS)	-Specialist nurse postdischarge follow-up -Assess symptoms, medication, and diet compliance -Reinforce education -Predetermined questionnaire and standardized intervention procedures	-Initial call within 1 week -Calls weekly for 1st month, biweekly for 2nd month, and then continue monthly -Follow-up frequency based on symptoms, knowledge, and needs
TM	-Specialist nurse monitoring of data -Daily weight, blood pressure, heart rate, EKG, performance status, medication compliance monitoring -Regularly scheduled primary care visits for reports	-Supervising center monitored and contacts patient if preset value of monitoring variable was exceeded -Designated personal advisor phoned patient -Status reports reviewed at follow-up primary care visits
Multidisciplinary (MI)	-Specialist postdischarge follow-up -Education pre/postdischarge -Individual follow-up with specialist physician, dietitian, psychologist, social worker, pharmacist pre- and postdischarge -Multidisciplinary patient visits	-Initial visit within 2–7 days (primary care or specialist) -Follow-up with individual specialist providers or multiprovider group sessions if available -Follow-up frequency determined by clinical status, symptoms, knowledge, and needs
CM	-Postdischarge follow-up -Education pre/postdischarge, specialist nurse home visits, scheduled telephone calls -Specialist physician and nurse-driven treatment protocol and coordination of care	-Primary care visit within 2 weeks -Specialist follow-up every 3 months at minimum -Follow-up with individual providers (compared to multidisciplinary visits of MI) -Frequency determined clinical status, symptoms, knowledge, and needs
Specialty nurse home visit	-Postdischarge follow-up -Protocol-driven symptom management	-Initial visit within 1 week -Specialist available if variation from protocol needed -Follow-up frequency based on clinical status, symptoms, knowledge, and needs

(continued)

Table 4. Continued

Comprehensive care plan (CCP) intervention recommendations for Pulmonary Hypertension Clinics Recommend combination intervention of below therapies Possible exception of adding CM to TM—did not show benefit in one study[25] Optimal intervention strategy may be resource, medical center, and provider dependent.		
Intervention	Components of intervention	Purpose/timing
Pharmacist home visit	-Postdischarge follow-up -Reinforcement of education, medication compliance, review of medications, and possible side effects -As needed follow-up depending on changes in medical management	-Initial visit within 1 week -Part of the comprehensive care plan team of MI -Follow-up frequency based on clinical status, symptoms, knowledge, and needs
Specialist physician clinic visit	-Postdischarge follow-up -Reassessment of performance status, medication titration, knowledge reinforcement, and diagnostic testing if needed -Coordination to other specialists	-Initial visit within 2–8 weeks -2- to 4-month initial interval follow-up -Primary care visits between specialist visits as indicated -Follow-up frequency based on clinical status, symptoms, knowledge, and needs
Primary care physician visit	-Postdischarge follow-up -Routine clinical evaluation, assessment of performance and need for change in frequency of follow-up -Review of TM data reports and coordinating provider management plans	-Initial visit 2 weeks postdischarge -Interspersed between specialist visits -Frequency based on symptoms, knowledge, and needs

CM: case management; TM: tele-monitoring; STS: structured telephone strategy; EKG: electrocardiogram; MI: multidisciplinary intervention.

CM versus CM plus TM

To further identify which interventions were most beneficial, a randomized control trial (RCT) by Wade et al.[7] compared CM and CM plus TM. The result was no significant difference in hospital admission, death, or emergency department visits, suggesting the addition of TM to CM may not provide additional patient benefit.

MI versus MI plus TM

Vuorinen et al.[16] performed an RCT that compared MI and MI plus TM. The combined intervention of MI plus TM did not improve the primary outcome of HF-related hospital days. Of note, health care resources in the combined group were significantly higher including contacts between nurse and patient, visits to nurse reception, and unplanned cardiology clinic visits.

We were not able to identify studies directly comparing STS to CM or STS to MI.

Based on review of available literature and intervention strategies, we suggest a comprehensive care plan (CCP) that enlists a combination of STS, home TM and MIs. A list of interventions and their components is available in Table 4. First and foremost, prior to implementing these strategies, it is imperative that CCP team members are adequately educated regarding disease process, prognosis, medication, and provider-specific treatment goals.

Discussion

Clinical implications

Presently, there is no consensus on the most effective outpatient management of PH or strategies to reduce hospital readmission. Successful CHF interventions can provide us with a starting point as we aim to develop and validate PH-specific interventions and comprehensive care programs.

Important factor that likely contribute to the success of these management programs is determining which patient information is most beneficial to monitoring and decision making. Although this article did not investigate which specific data points would be helpful, other articles have. Kane et al.[40] showed an improved concordance statistic (c-index) of 0.84 for predicting mortality when predominantly noninvasive clinical parameters (gender, age, disease duration, 6-min walk test, hemoglobin, glomerular filtration rate, BNP, echocardiography, pulmonary function tests, RHC) were used in addition to World Health Organization functional class. The c-index for functional class alone was 0.60, and when the Registry to Evaluate Early and Long-Term PAH Disease Management (REVEAL) score was validated

in their cohort, the c-index was 0.71. These parameters along with multifaceted CCP may further enhance patient management.

Limitations

There were some limitations identified during this review. They include the extrapolation of data and interventions from CHF to PH based on disease and patient similarities. Secondly the duration of time between the original articles (1993–2019). While comprehensive, it should also be considered that medical and interventional techniques for heart failure management have changed, and standards of care improved over time. Another consideration is the proportion of PH patients managed with parenteral therapies. They are often managed by expert PH centers and may already have a system in place which provides close monitoring of their clinical status. It would need to be determined if those current management systems would benefit from modification or replacement with the above alternative systems. Lastly, individual patient's familiarity and ability to interact with the technology being used to monitor and collect data may be a limiting factor. Those with more technological aptness may be able to provide data more consistently and reliably. In an era of smart devices, this opens the door to development of applications and monitoring programs that could more easily integrate into the daily lives of patients.

Conclusion

In conclusion, we have identified a gap in the current outpatient care and management of PH patients that may be amenable to the implementation of CHF interventions described by our cardiology colleagues given possible patient similarities within the two disease states. The relatively benign nature of these interventions is also particularly attractive. Based on our review, management plans must focus on predischarge, discharge, and postdischarge education for the patient and family members with specific attention to disease process, medication, diet, and self-monitoring. Patients from the community who do not require hospitalization and are able to be seen in the specialist clinic initially should begin their evaluation in similar sequence to that of postdischarge patients. We suggest that strategies to improve the health of PH patients should include STS and TM in addition to the patient-centered approach of multidisciplinary intervention (MI). Regarding IHM devices, the evidence presented in cardiology trials and early data in PAH trials suggest there may be benefit in extrapolating their routine use to PAH patients. However, due to their invasiveness, such an intervention requires further validation prior to being recommended. Which intervention or combination of interventions implemented may require tailoring to the individual institution depending on patient needs and resource availability. Further follow-up studies are needed to identify which interventions are most beneficial to this particular patient population in addition to cost effectiveness of care.

Disclaimer

The views expressed in this article are the view of the authors listed and not the official position of the institutions.

Author contributions

FR conceived of the presented idea. JD developed the theory and performed the data search and interpretation. FR and JD investigated outpatient congestive heart failure management strategies. All authors discussed the results and contributed to data analysis and development of the final manuscript.

Conflict of interest

JD, JPM, VN, and SM have nothing to disclose. JT reports personal fees from United Therapeutics, personal fees and nonfinancial support from Medtronic, Inc., and personal fees and nonfinancial support from United Therapeutics, outside the submitted work. MC reports grants and personal fees from Actelion, grants and personal fees from Bayer, personal fees from United Therapeutics, grants and personal fees from Reata, grants from Eiger, grants from Novartis, grants from Liquidia, grants from Complexa, grants and personal fees from Phase Bio, grants and personal fees from Arena, grants from Medtronic, personal fees from Gilead, personal fees from Express Scripts, and personal fees from Akros, outside the submitted work. FR is a researcher, consultant, and speaker for Actelion, Bayer, and United Therapeutics. He is also a researcher and consultant for Acceleron. He reports grants and personal fees from Actelion, grants and personal fees from Bayer, personal fees from United Therapeutics, and grants and personal fees from Acceleron, outside the submitted work.

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