Clinical Pharmacy Services in Heart Failure: An Opinion Paper from the Heart Failure Society of America and American College of Clinical Pharmacy Cardiology Practice and Research Network

Sherry K. Milfred-LaForest, Sheryl L. Chow, Robert J. DiDomenico, Kathleen Dracup, Christopher R. Ensor, Wendy Gattis-Stough, J. Thomas Heywood, JoAnn Lindenfeld, Robert L. Page, II, J. Herbert Patterson, Orly Vardeny, and Barry M. Massie

Heart failure (HF) care takes place in multiple settings, with a variety of providers, and generally involves patients who have multiple comorbidities. This situation is a "perfect storm" of factors that predispose patients to medication errors. The goals of this paper are to outline potential roles for clinical pharmacists in a multidisciplinary HF team, to document outcomes associated with interventions by clinical pharmacists, to recommend minimum training for clinical pharmacists engaged in HF care, and to suggest financial strategies to support clinical pharmacy services within a multidisciplinary team. As patients transition from inpatient to outpatient settings and between multiple caregivers, pharmacists can positively affect medication reconciliation and education, assure consistency in management that results in improvements in patient satisfaction and medication adherence, and reduce medication errors. For mechanical circulatory support and heart transplant teams, the Centers for Medicare and Medicaid Services considers the participation of a transplant pharmacology expert (e.g., clinical pharmacist) to be a requirement for accreditation, given the highly specialized and complex drug regimens used. Although reports of outcomes from pharmacist interventions have been mixed owing to differences in study design, benefits such as increased use of evidence-based therapies, decreases in HF hospitalizations and emergency department visits, and decreases in all-cause readmissions have been demonstrated. Clinical pharmacists participating in HF or heart transplant teams should have completed specialized postdoctoral training in the form of residencies and/or fellowships in cardiovascular and/or transplant pharmacotherapy, and board certification is recommended. Financial mechanisms to support pharmacist participation in the HF teams are variable. Positive outcomes associated with clinical pharmacist activities support the value of making this resource available to HF teams.

Key Words: heart failure, clinical pharmacist, multidisciplinary team, heart transplant.

(**Pharmacotherapy 2013;33(5):529–548**)

Introduction

In the mid-1980s, Hepler and Strand introduced the term "pharmaceutical care," promoting a paradigm shift for the pharmacy profession toward care that focused on improving outcomes and safety associated with drug therapy (referred to as "clinical pharmacy services" for the remainder of this document).[1, 2] Since then, clinical pharmacists, i.e., pharmacists who have advanced training, certification, and/or experience in a specific practice setting and/or disease state(s) and provide clinical pharmacy services, have taken on expanded roles, and they now routinely identify and resolve drug-related problems to improve clinical outcomes.[1–3] Table 1 depicts eight categories of drug-related problems and common examples in HF patients. Clinical pharmacy services include: accurate medication reconciliation; developing patient care plans including the selection, dosing, and monitoring of drug therapy; promoting medication adherence; and educating patients and other health care providers regarding complexities of drug therapy.[4] Clinical pharmacy services have been shown to reduce length of hospital stay, medication errors, adverse drug reactions, and costs, and to improve survival.[4–12]

Clinical pharmacists have participated in multidisciplinary disease management programs for chronic diseases such as hypertension, diabetes, and dyslipidemia. In those settings, the value of clinical pharmacist involvement has been demonstrated by improvements in lipid levels, blood pressure control, hemoglobin A_{1c}, and adherence with evidence-based performance measures.[13–19] As with other chronic diseases, disease management programs for HF also have demonstrated improved outcomes. Rich et al.[20] published one of the early descriptions of a multidisciplinary team intervention in HF. That nurse-directed intervention reduced readmission rates by > 50%, improved quality of life, and reduced costs. Since then, a number of studies have supported the benefit of multidisciplinary interventions in HF.[21–24]

Heart failure is one of the most common and costly illnesses in the United States because of high rates of hospitalization. Although current pharmacotherapy has improved survival in patients with HF, morbidity and mortality remain high.[25] Following an admission for HF, as many as 44% of patients are readmitted within the next 6 months.[26] Causes for readmission include disease progression, suboptimal medication management or nonadherence, and non-HF–related comorbid conditions. In addition to high morbidity and cost, care of HF patients can be complicated and fragmented. Patients with HF in the contemporary health care era visit multiple providers for a variety of comorbidities and complex care plans driven by clinical practice guidelines that are almost exclusively focused on individual disease processes.

From the Department of Pharmacy, Louis Stokes Cleveland VA Medical Center, Cleveland, Ohio (S.K. Milfred-LaForest); College of Pharmacy, Western University of Health Sciences, Pomona, California (S.L. Chow); College of Pharmacy, University of Illinois at Chicago, Chicago, Illinois (R.J. DiDomenico); School of Nursing, University of California, San Francisco, California (K. Dracup); College of Pharmacy, University of Pittsburgh, Pittsburgh, Pennsylvania (C.R. Ensor); Campbell University, College of Pharmacy and Health Sciences, Department of Clinical Research, Buies Creek, North Carolina (W. Gattis-Stough); Department of Medicine, Scripps Clinic, La Jolla, California (J.T. Heywood); Heart Transplantation Program, Department of Medicine, Division of Cardiology (J. Lindenfeld), and Schools of Pharmacy and Medicine, University of Colorado Denver, Aurora, Colorado (R.L. Page, II); Eshelman School of Pharmacy, University of North Carolina, Chapel Hill, North Carolina (J.H. Patterson); Schools of Pharmacy and Medicine, University of Wisconsin, Madison, Wisconsin (O. Vardeny); School of Medicine, University of California, and San Francisco VA Medical Center, San Francisco, California (B.M. Massie).

Robert J. DiDomenico is a consultant for F. Hoffman LaRoche. J. Thomas Heywood has received speaking honoraria from Actelion, Medtronic, St Jude, and Thoratec; is a consultant for Actelion, Medtronic, and Thoratec; and has received research grants from Medtronic and Gambro and fellowship support from St. Jude. JoAnn Lindenfeld is a consultant for St Jude, Boston Scientific, and Abbott and has received a research grant from Zensun. J. Herbert Patterson has received speaking honoraria from Otsuka, is a consultant for Otsuka and Novartis, and has received research grants from Otsuka, Novartis, and Amgen. All of the other authors report no potential conflict of interest.

This paper represents the opinions of the Cardiology Practice and Research Network of the American College of Clinical Pharmacy (ACCP) and the Heart Failure Society of America (HFSA). It does not necessarily represent an official ACCP or HFSA commentary, guideline, or statement of policy or position.

For questions or comments, contact Sheryl L. Chow, Western University of Health Sciences, College of Pharmacy, 309 E. Second Street, Pomona, CA 91766; e-mail: schow@westernu.edu or Barry M. Massie, San Francisco VAMC, Cardiology Division (111C), 4150 Clement Street, San Francisco, CA 94143; e-mail: barry.massie@va.gov.

This article was published in the *Journal of Cardiac Failure*, Vol 19, Issue 5, May 2013, Milfred-Laforest et al, "Clinical Pharmacy Services in Heart Failure: An Opinion Paper From the Heart Failure Society of America and American College of Clinical Pharmacy Cardiology Practice and Research Network"

Table 1. Eight Categories of Drug-Related Problems

Drug-Related Problem	Description	Example in Heart Failure (HF)
Untreated indications	Patient has an indication that requires drug therapy but is not receiving any drugs for that indication.	Omission of ACE inhibitor from discharge medication list in a patient with reduced LVEF without documentation of contraindication and/or plan for when to restart after discharge.
Improper drug selection	Patient is taking the wrong drug for stated indication.	Patient with acute decompensated heart failure receiving dronedarone for atrial fibrillation.
Subtherapeutic dosage	Patient is being treated with too little of the correct drug for their medical problem.	Patient with HF and blood pressure > 135/85 mm Hg and heart rate > 75 bpm on 5 mg lisinopril daily and 6.25 mg carvedilol twice daily.
Failure to receive drugs	Patient has a medical problem resulting from not receiving a drug (e.g., for pharmaceutical, psychologic, sociologic, or economic reasons).	Patient is unable to fill prescribed medications after discharge from HF admission owing to cost or inability to get to pharmacy.
Overdosage	Patient is being treated with too much of the correct drug (toxicity).	Patient with NYHA functional class IV HF and reduced LVEF on digoxin with trough serum concentration of 1.7 ng/ml.
Adverse drug reactions	Patient has a medical problem resulting from an adverse drug reaction or adverse effect.	Patient with NYHA functional class III HF experiencing increased edema after initiation of pioglitazone.
Drug interactions	Patient has a medical problem resulting from a drug–drug, drug–food, or drug–laboratory interaction.	Patient with worsening renal function in setting of combination of ACE inhibitor and over-the-counter NSAID use.
Drug use without indication	Patient is taking a drug for no medically valid indication.	Continuation of proton pump inhibitor after discharge when initiated for stress ulcer prophylaxis during HF admission, in the absence of other documented indication.

ACE = angiotensin converting enzyme; bpm = beats per minute; LVEF = left ventricular ejection fraction; NYHA = New York Heart Association; NSAID = nonsteroidal antiinflammatory drug.
Adapted from references 1–3.

The goals of the present paper are to describe activities of clinical pharmacists within a multidisciplinary HF team, to document areas where clinical pharmacist interventions have resulted in improved outcomes, to summarize recommended training and qualifications for a clinical pharmacist in this area, and to describe potential strategies to provide financial support for clinical pharmacy services within a multidisciplinary team.

Clinical Pharmacist Roles Across the Continuum of Heart Failure Care

Although each practice setting (i.e., inpatient vs outpatient care) provides a unique opportunity for clinical pharmacist contributions, there are a few services that are consistent across all areas of patient care. These include early identification and prevention of adverse drug reactions and interactions, therapeutic drug monitoring, medication reconciliation, and promoting medication adherence.

Prevention of Adverse Drug Reactions and Medication Errors

Consequences of adverse drug reactions (ADRs) and medication errors can affect admission rates, length of stay, and quality of care.[27–29] In one series, 62% of ADRs contributing to hospital admissions were deemed to be preventable, and > 40% of the preventable ADRs were attributed to cardiovascular or anticoagulant medications.[28] Clinical pharmacy services in general have been shown to decrease the rate of ADRs and other medication errors by 25–40%, and clinical pharmacists in the intensive care unit (ICU) can reduce the rate by > 60%.[6, 11, 30, 31] Clinical pharmacists in a coronary care unit (CCU) identified medication errors at an alarming frequency (24 medication errors/100 admissions).[32] Murray et al.[33] described a pharmacist intervention consisting of medication profile and laboratory review, patient education, and communication with providers for outpatients with hypertension and/or HF.

During the 12-month study period, a 34% relative risk reduction in ADRs was observed in the intervention group compared with control. The most common ADRs were renal insufficiency and drugs to avoid in the elderly.[33]

Therapeutic Drug Monitoring

Therapeutic drug monitoring (TDM) is an important aspect of patient care, and clinical pharmacists are particularly well suited for this role. A typical patient with HF takes ≥ 6 medications and has ≥ 5 chronic conditions, which can potentially lead to drug–drug interactions as well as serious life-threatening adverse events, such as hyperkalemia or torsades de pointes.[34, 35] For HF patients treated chronically with narrow therapeutic index medications such as digoxin and warfarin, dosing adjustments are required when concomitant antibiotics, amiodarone, or other cytochrome P450/P-glycoprotein inhibitors or inducers are prescribed. In the acutely decompensated patient, alterations in renal function and hepatic blood flow will also warrant significant dosing changes (e.g., for dofetilide, digoxin, or warfarin).[35] Other medications such as mineralocorticoid receptor antagonists (MRAs) have been shown to prevent morbidity and mortality in HF, but carry a risk for hyperkalemia and necessitate ongoing close monitoring.[36–38] Potential drug interactions can be reduced with the use of computerized order entry systems, but studies have shown that input errors and incomplete decision support can occur.[39, 40] Clinical pharmacists provide pharmacokinetic monitoring and assessment of drug interactions through review of medication profiles, laboratory data, and patient interviews, and make recommendations to the medical team or patient regarding appropriate monitoring tests or dosage adjustments.[6, 41, 42]

Medication Reconciliation

Medication reconciliation is a critical component of safe medication use and has been incorporated into the Joint Commission National Patient Safety Goals.[43] Patients are most susceptible to medication errors related to inaccurate medication histories during transitions in care.[32, 44, 45] Complex medical regimens for HF and other comorbidities increase the likelihood for medication reconciliation discrepancies. Numerous studies have found that pharmacists significantly reduce medication errors and improve patients' knowledge retention at the time of admission, discharge, and post-hospitalization follow-up when they are involved in medication reconciliation.[45–56] Pharmacists involved in a multidisciplinary postdischarge HF medication reconciliation clinic found that 52% of patients had at least one medication discrepancy from the prescribed discharge regimen at the follow-up visit, despite the majority receiving discharge counseling during the hospitalization.[54]

Medication Adherence and Access

Nonadherence is a major contributor to the underutilization of evidence-based HF therapies. In an analysis of 54,322 HF hospitalizations from the Get with the Guidelines–HF registry, medication nonadherence contributed to hospital admission in 7.9% of subjects.[57] In a retrospective claims analysis of > 45,000 Medicaid beneficiaries over a 2-year period, 11.8–20.1% of patients with HF claims did not have a single claim for evidence-based HF medications and were deemed to be nonadherent.[58]

Nonadherence with evidence-based medications and other instructions is often multifactorial. It may be related to inadequate patient education, poor retention of information provided during hospitalization, cognitive impairment, economic barriers, lack of adequate social support, and poor health literacy. Studies have shown that pharmacist interventions such as discharge counseling or home-based education to improve adherence and optimize medications result in a reduction in hospitalizations.[21, 52, 54, 59] A primary focus of clinical pharmacy services is identifying barriers to medication adherence or access (e.g., affordability of medications) and finding ways they can be addressed. Strategies may include patient education, regimen simplification, and finding lower-cost alternative medications where appropriate.

Cost of medications can be a particular burden with some evidence-based medications for cardiovascular disease or immunosuppressive agents after transplantation. In those cases, clinical pharmacists often serve as a resource for information on alternative prescription drug coverage. Many pharmaceutical companies offer programs that provide medication to eligible patients at reduced or no cost.[60] Programs for immunosuppressive medications can be a major source of financial assistance for transplant

patients. These medication assistance programs have gained in popularity over the past decade, but remain underutilized. Enrollment into these programs can be initiated by the patient, their advocate, or a health care provider. Patient financial documentation is usually required. Once accepted into the program, medications are dispensed directly to the patients' residence, through use of a voucher at a pharmacy, or delivered to the provider's office.

Role of the Pharmacist in the Clinical Management of Hospitalized Patients with Heart Failure

Two papers have defined the clinical roles of the critical care pharmacist and endorsed a best practice model for delivery of these services. A joint task force from both the Society of Critical Care Medicine (SCCM) and the American College of Clinical Pharmacy (ACCP) published a position paper defining the level of pharmacy practice and specialized skills required for the provision of clinical pharmacy services to critically ill patients.[61] Institutions were encouraged to strive for the highest level of clinical pharmacy service possible. Those recommendations were also endorsed in a more recent position paper defining the clinical pharmacist roles and best practice model for critical care delivery.[62]

Clinical pharmacists have assumed larger roles in the care of patients in the ICU and CCU. Numerous analyses support inclusion of clinical pharmacists in a multidisciplinary team caring for patients with cardiovascular disease in general and HF in particular.[63–65] In 2003, Kane et al.[31] summarized 14 published reports evaluating the clinical and economic outcomes associated with critical care pharmacy services in various critical care settings (medical, surgical, cardiac, and pediatric). The most common critical care pharmacy interventions involved clarifying drug orders and identification and resolution of drug-related problems, leading to fewer medication errors and adverse events. Those services decreased annual institutional costs by $25,140—$270,000. Other studies added to the evidence of the favorable economic benefit of clinical pharmacy services in the CCU. White and Chow investigated the clinical and economic benefits of focused rounds by clinical pharmacists in the CCU.[66] Over a 14-day period, 61 interventions occurred, resulting in an estimated net cost savings of $2219, which extrapolates to > $57,000 in annual savings (1998 dollars). Likewise, Gandhi et al assessed the economic benefit of clinical pharmacy services in the CCU and estimated a cost savings from clinical pharmacy interventions of $372,383 during calendar year 1999.[67] Interventions performed with the greatest frequency or highest economic impact in those two trials are presented in Table 2.

Role of Pharmacists in Ensuring Quality Measures for Patients With Heart Failure

Since 2004, the Joint Commission has implemented core measures for HF as an accreditation requirement for hospitals.[68] Those four core measures require documentation of assessment of left ventricular ejection fraction, angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) use in patients with left ventricular systolic dysfunction, documentation that patients received discharge instructions, and adult smoking cessation counseling.

Many patients hospitalized for HF, particularly those with a history of HF with left ventricular dysfunction, may not have been treated with evidence-based medications at the time of admission. United States and international registries suggest low utilization rates of ACE inhibitors or ARBs (< 70%) and beta-blockers (< 75%), and very low utilization rates of MRAs (< 20%) before admission in patients hospitalized for HF.[57, 69–75] Even when prescribed, HF medications may not be given in doses that have been demonstrated to improve outcomes. Although utilization rates are higher at the time of discharge, ACE inhibitors or ARBs (82–93%), evidence-based beta-blockers (72–95%), and MRAs (21–65%) remain underutilized in many patients, resulting in higher rates of rehospitalization and mortality.[73–78] As a member of the HF multidisciplinary team, the clinical pharmacist can ensure initiation of ACE inhibitors/ARBs, beta-blockers, and MRAs in all appropriate patients and that contraindications, intolerance, or other reasons for not prescribing such therapies are clearly documented.[79, 80]

Evidence to Support Value of Pharmacists with Improving Quality Metrics

The development of accountable care organizations under the Medicare Shared Savings Program will result in reimbursement based on

Table 2. Frequent Clinical Pharmacist Interventions in Coronary Care Unit

Intervention	Subtypes of Interventions Performed
Drug information	Provide patient-specific drug information to provider or medical team in written form or verbally during rounds
Therapeutic consultation	Addition/dosage titration of agent with proven mortality benefit
	Recommend therapeutically indicated drug therapy for both cardiovascular and noncardiovascular conditions
	Recommend discontinuation of contraindicated medications and/or medications without an indication
	Adjust dose based on renal or hepatic function or serum drug concentrations
	Recommend additional laboratory testing for therapeutic monitoring of medication
	Adjust drug therapy based on laboratory parameters, physical findings, electrocardiogram, and other diagnostic tests
	Optimize titration or weaning regimen
	Clarify drug allergy/intolerance and recommendation of alternate therapies if necessary
Order clarification and formulary maintenance	Clarify provider orders to improve patient safety
	Suggest equivalent formulary alternative to nonformulary item considering efficacy, cost, and patient safety
	Convert intravenous dosage formulations with good bioavailability to oral dosage forms
	Evaluate appropriateness of generic immunosuppressive medications
Antimicrobial regimen adjustment	Recommend changes to antibiotic regimens, as needed, to improve spectrum of coverage and/or antimicrobial activity based on clinical response, culture/sensitivity data, or appropriate duration of therapy
	Modify antibiotic dosing or frequency
Drug interaction avoided	Identify potential drug–drug, drug–nutrient, and drug–disease interactions
	Adjust or discontinue medications to prevent interactions
	Identify and resolve intravenous drug incompatibilities
Duplication of therapy	Identify potential therapeutic duplication of new drug with existing active orders
Quality improvement	Participate in multidisciplinary clinical pathway development, monitoring, and dissemination
	Assist multidisciplinary teams with monitoring and adherence to quality performance measures

Adapted from references 66 and 67.

comparative hospital performance measures and benchmarks, and further underscores the importance of documenting and delivering best-practice standards within hospital institutions.[81, 82] As adherence to performance measures begins to affect reimbursement, institutions use clinical pathways and guideline-based order sets. Pathways developed and implemented by multidisciplinary teams, including physicians, nonphysician providers, nurses, and pharmacists, have been shown to improve adherence to performance measures, medication safety, and outcomes.[61,64,80,83–85] Clinical pharmacists can provide recommendations about drug dosing and monitoring parameters built into the order set, and implementation strategies. Furthermore, the clinical pharmacist can disseminate and provide training for critical pathways throughout the hospital.

Clinical Pharmacist Activities in Care Transitions for Heart Failure Patients

Role of Pharmacist in Discharge Education

Patient education is the final, critical step in the discharge process as the patient moves from hospital care to self-care at home. Although it is clear that discharge education alone is not sufficient to lead to full retention of information, it is often an early step in the process. Clinical pharmacists can use their expertise in drug therapy to inform HF patients regarding the safe and effective use of medications. Additionally, participating in the patient's discharge education provides another opportunity for the clinical pharmacist to reinforce HF-related information discussed with the patient by other providers. Finally, it provides an opportunity for the pharmacist to facilitate dispensing of medications at the time of hospital discharge and for long-term adherence with the treatment plan.

The American College of Clinical Pharmacy Cardiology PRN has recently published a Best Practices Model for discharge counseling of patients hospitalized for myocardial infarction and HF.[86] The model describes a patient-centered approach that reinforces ongoing learning by the patient after discharge and provides some strategies to consider for improving medication adherence, including a focus on health literacy and barriers such as financial hardship. For HF patients, it is recommended that education include: information on the disease state, includ-

ing risk factors, complications, and signs and symptoms of exacerbation; safe and appropriate use of medications; the postdischarge plan for follow-up; therapeutic interventions aimed at controlling modifiable risk factors for HF; and lifestyle modifications.[86] Counseling patients and family can resolve barriers to implementation of the therapeutic regimen. Successful interventions provide consistent education with the use of similar verbal and written information by multiple health care professionals (e.g., pharmacist, bedside nurse, advanced practice nurse, physician), providing reinforcement of key points.

Evidence to Support the Value of Pharmacists in Discharge Education

Several studies have described the benefits of structured discharge education programs or services for HF patients that include clinical pharmacist participation.[87] A summary of those studies, which include intensive inpatient medication teaching and follow-up telephone contact after discharge, is provided in Table 3.[87–90] Several initiatives were associated with improved clinical outcomes, including a reduction in death, emergency department (ED) visits, or rehospitalization.[89–91] However, a recent large study did not show any difference between pharmacist-provided medication reconciliation and tailored discharge education and standard medication reconciliation and discharge education on the incidence of postdischarge medication errors in a population with good health literacy.[88] Because patient education must be an ongoing continuous process, education of HF patients initiated during hospitalization and reinforced during follow-up may be more successful than education performed at either time point alone. The multidisciplinary nature of many of these educational interventions suggests that benefit is derived from a team approach which includes a clinical pharmacist.

Clinical Pharmacists as Members of the Outpatient Heart Failure Team

A major focus in HF care for health systems is minimizing hospitalizations. Hospital readmission negatively affects mortality and is a primary driver of costs. Therefore, efforts to improve outpatient care are important, and clinical pharmacy services have demonstrated benefit in the outpatient HF setting.

Role of the Pharmacist in the Outpatient Setting

Pharmacists have served as part of a multidisciplinary HF clinic or have evaluated patients as single providers. The multidisciplinary approach involves time with the pharmacist, nurse, and/or physician. In that setting, pharmacists perform medication reconciliation, order necessary laboratory assessments, screen for drug–drug interactions, and provide education about outpatient medications. As a single provider, the pharmacist often evaluates a patient for up-titration and monitoring of HF medications per referral from another HF provider.

Evidence to Support the Value of Pharmacists in the Outpatient Setting

One of the early trials documenting the role of a clinical pharmacist within an outpatient HF team was the Pharmacist in Heart Failure Assessment Recommendation and Monitoring Study conducted by Gattis et al.[92] The intervention consisted of medication education by a clinical pharmacist, optimization of the patient's drug regimen in concert with the patient's provider, and telephone follow-up to identify drug therapy issues. The control group received standard care. The primary end point was a combination of all-cause mortality and nonfatal HF events (ED visits and hospitalizations). The intervention group had significantly fewer nonfatal HF events than the control group (9% vs 25%); however, all-cause mortality was low and did not differ between groups. Another recent study, conducted within the National Health Service in the United Kingdom, randomized individuals with HF and reduced left ventricular systolic function but low risk of decompensating or minimal symptoms to a 30-minute medication optimization intervention by a pharmacist versus usual care. The primary outcome was the composite of death from any cause or hospital admission for worsening HF. There was no difference noted in the primary outcome between groups, although the intervention group had statistically higher rates of ACE inhibitor, ARB, or beta-blocker initiation or dose titration compared with usual care.[93] Riegel et al.[23] described a multidisciplinary disease management program that included nurses, a pharmacist, dieticians, social workers, and physicians. The program reduced HF readmissions by 29%. Other randomized controlled trials have

reported the impact of pharmacists in specialized HF clinics and in home-based interventions (Table 4). Those trials demonstrated increased adherence, improved symptoms, and reduced HF hospitalization or ED visits.[59, 94–96]

A recent systematic review evaluated pharmacist-directed or pharmacist-collaborative interventions conducted within a multidisciplinary team.[87] Nine of the 12 studies included in that meta-analysis were completed in an outpatient setting. Studies with pharmacist-based interventions reported positive outcomes on rehospitalization, both all-cause and HF hospitalizations, with more pronounced effects observed in multidisciplinary settings compared with pharmacist-directed care alone. Effects on mortality were not statistically significant, possibly because of the relatively small sample sizes and short follow-up times of most studies.

Clinical Pharmacist on the Transplant/ Mechanical Circulatory Support Team

Heart failure programs offering heart transplantation and mechanical circulatory support (MCS) as options for care rely on a multidisciplinary team approach—including cardiologists, surgeons, nurses, social workers, and clinical pharmacists—to provide effective care across the transplant continuum. With the complex pharmacokinetics of current immunosuppressive drugs, the clinical pharmacist's expertise to identify potential drug–drug interactions and adverse events and to provide patient specific dosing, monitoring recommendations, and medication education also is needed on the transplant team.[97–99] The American Society for Transplantation (AST) Transplant Pharmacy Community of Practice recently published a white paper on the fundamental and recommended roles of, and optimal training for, clinical pharmacists working within a transplant team.[100]

The United Network for Organ Sharing (UNOS) amended their bylaws in June 2004 to include a clinical pharmacist as an essential member of the transplant team.[101] That organization recommended specific responsibilities that cover a spectrum of solving medication-related problems to monitoring of patient care plans. Table 5 summarizes information from both AST and UNOS guidelines regarding responsibilities of a transplant clinical pharmacist in various phases of the transplantation process.

In 2007, the Centers for Medicare and Medicaid Services (CMS) published Medicare Conditions of Participation for organ transplant programs.[102] In its final rule, CMS mandated that for a transplant program to be reimbursed for their services, programs must meet certain minimum criteria. One criterion stated that every transplant program must have a designated qualified expert in transplant pharmacology who should serve as a member of the multidisciplinary transplant team. This transplant pharmacology expert must be involved in every patient's care at multiple phases of the transplantation process to maintain transplant center accreditation. This involvement should include pretransplantation (transplantation evaluation and advanced HF care), perioperative, and postoperative inpatient and outpatient care.

Role of the Pharmacist in Mechanical Circulatory Support

Today, there are > 20 MCS devices in clinical use or development worldwide.[103] Although MCS devices provide a benefit regarding medical therapy for end-stage HF, their use is associated with significant morbidities requiring advanced pharmacotherapeutic knowledge.[103–106]

The clinical pharmacist may provide significant benefits in several areas within the MCS field, such as pharmacotherapeutic interventions which may reduce perioperative hemostasis and improve outcomes with thrombosis prophylaxis.[103, 107] Minimization and management of adverse events include inotrope selection and titration for right ventricular failure, antiarrhythmic therapy, prevention and treatment of gastrointestinal bleeding, prevention of neurologic events, and antimicrobial management and selection and dosing for pump-associated infections.[103] Limited data are available regarding the value of the pharmacist in MCS; as more hospitals acquire the capability for MSC, evidence will likely accumulate regarding the potential benefit of a multidisciplinary approach to management of these patients.

Role of the Pharmacist in the Management of the Heart Transplant Patient

Pretransplantation Phase

The transplant pharmacist may also provide a pretransplantation assessment of potential medication adherence barriers after transplantation

Table 3. Trials Evaluating Clinical Pharmacist Discharge Education

Citation	Study Design	Primary End Point(s)	Results	Comments
Eggink et al.[52]	RCT. Eighty-five adults with HF (control: n=44; intervention: n=41) admitted with HF and prescribed $\geq$5 medications at discharge. Pharmacist intervention: identifying prescription errors and counseling (verbal and written information) about side effects and future changes in medication.	Cumulative % of prescription errors and discrepancies after discharge	$\geq$1 discrepancy or prescription error: control: 68%; intervention: 39%; RR 0.57 (95% CI 0.37–0.88). % of medications with discrepancy or prescription error: control: 14.6%; intervention: 6.1%; RR 0.42 (95% CI 0.27–0.66).	Study conducted in the Netherlands
Gwadry-Sridhar et al.[53]	RCT. One hundred and thirty-four patients with HF (control: n=66; intervention: n=68) and LVEF < 40% requiring long-term management. Pharmacist and nurse/educator as multidisciplinary intervention. Standard of care plus patient education on medication adherence, dietary, and lifestyle modification vs standard of care (control).	Compared QOL scores using the MLHFQ, noncompliance, and time to first event (mortality, readmission, or ED visit)	Intervention group: higher knowledge scores at discharge and 1 yr (p=0.05). Noncompliance produced variable results for ACE-I and diuretics. QOL improved (p=0.04). Composite end point improved in intervention but not significantly (HR 0.85, 95% CI 0.55–1.30).	Community pharmacists and general practitioners were blinded to patient assignment
Rainville et al.[91]	RCT. Thirty-four HF patients (17 in each group). Pharmacist and nurse specialist intervention. Standard of care plus: (i) modifiable patient-specific risk factors for readmission; (ii) patient education tools; (iii) medication changes to physician.	Hospital readmission for HF or death at 1 yr	Readmissions for HF over 1 yr: control: 10 (58.8%); intervention: 4 (23.5%); p<0.05. Death or readmission over 1 yr: control: 14 (82.3%); intervention: 5 (29.4%); p<0.01	Baseline characteristics were similar between groups. Most patients were receiving digoxin and an ACE-I.
Lopez Cabezas et al.[89]	RCT. One hundred and thirty-four patients (control: n=64; intervention: n=70) hospitalized for HF based on Framingham criteria. Intervention subjects received education on disease, diet, and drug therapy from a pharmacist at discharge and monthly follow-up phone calls for 6 mo and every 2 mo thereafter	Time to first readmission, % of patients readmitted, total no. of readmits, total hospital days during study period	Readmissions: 2 mo: control: 16 (25%); intervention: 8 (11.4%); p=0.041; 6 mo: control: 27 (42.2%); intervention: 17 (24.3%); p=0.028. Hospital days/patient lower in intervention group: 2 mo: 1.7 $\pm$ 7.7 vs 3.5 $\pm$ 7.8 (p=0.034); 6 mo: 4.3 $\pm$ 13.1 vs 6.8 $\pm$ 12.5 (p=0.02)	Treatment adherence was higher in the intervention group at 2 and 6 mo. Readmissions and hospital days/patient were lower at 12 mo, but the difference was not significant. Study conducted in Spain.

(continued)

Table 3. (continued)

Citation	Study Design	Primary End Point(s)	Results	Comments
REACT: Tsuyuki et al.[90]	RCT. Two hundred and seventy-six adult patients (control: n=136; intervention: n=140) hospitalized with primary, secondary, or complicating diagnosis of HF. Intervention subjects received education from a research pharmacist or nurse on diet, daily weighing, exercise, medications, and when to contact the physician. Education performed at discharge and via phone follow-up at 2 wk and 4 wk, then monthly.	Adherence with ACE-I at 6 mo	ACEI adherence:control: 86.2 ± 29%; intervention: 83.5 ± 31.2%; p=0.691	All-cause physician visits, ED visits, and readmissions were not significantly different. Cardiovascular-related ED visits were lower in intervention group (20 vs 49; p=0.03). Study conducted in Canada.
PILL-CVD: Kripalani et al.[88]	RCT. Eight hundred and sixty-two adult patients (intervention: n=430; control: n=432) hospitalized for ACS or HF at academic medical centers with EHR. Intervention group had a pharmacist perform medication reconciliation at admission and discharge and discharge counseling; counseling was tailored with low health literacy aids. Control group had medication reconciliation performed at admission and discharge using EHR and discharge education according to standard hospital procedure.	Clinically important medication errors, including preventable ADEs, within 30 day of discharge. Secondary end point was potential ADEs, including medication discrepancies, nonadherence, medication omission, and early filling of prescriptions.	Overall rate of clinically important medication errors was 50.8%: no difference between groups (0.87 vs 0.92 events/patient, IRR 0.92, CI 0.77–1.09); trend toward lower incidence in intervention arm in subgroup with low health literacy, but not statistically significant. Potential ADEs were reported in 29.7%. Fewer potential ADEs in the intervention group (0.44 vs 0.55 events/patient, IRR 0.79, CI 0.61–1.01).	Intervention designed to target patients with low health literacy, but only 19% of patients in the study had low or marginal health literacy. Medication errors were adjudicated with a 30-day follow-up phone call and retrospective review of medical records and included worsening or new symptoms and health care utilization. All patients received medication reconciliation and discharge counseling by a health care professional, so may have been difficult to detect incremental difference.

ACE-I = angiotensin-converting enzyme inhibitor; ACS = acute coronary syndrome; ADE = adverse drug event; CI = confidence interval; ED = emergency department; EHR = electronic health record; HF = heart failure; HR = hazard ratio; IRR = incidence rate ratio; LVEF = left ventricular ejection fraction; MLHFQ = Minnesota Living With Heart Failure Questionnaire; QOL = quality of life; RCT = randomized controlled trial; RR = relative risk.

Table 4. Trials Evaluating Clinical Pharmacy Services in an Outpatient Heart Failure Setting

Citation	Study Design	Primary End Point(s)	Results	Comments
Stewart et al.[21]	RCT. n=97. Recent HF hospitalization, randomized to home-based intervention by nurse/pharmacist team within 1 wk of discharge or usual care. Intervention: assessment of patient knowledge, adherence and targeted education; assessment of early decompensation or adverse effects.	Unplanned readmissions within 6 mo plus out-of-hospital deaths	Fewer unplanned hospitalization (36 vs 62; p=0.03); fewer total hospital days (261 vs 452; p=0.05); trend toward fewer total and out-of hospital deaths (p=0.11) in intervention group; fewer patients in intervention group admitted ≥ 3 times (0 vs 5; p=0.02)	Single in-home postdischarge visit. Decreased hospital days driven largely by decrease in multiple readmissions.
Varma et al.[94]	RCT. n=83. Older adults in Northern Ireland. Pharmacist intervention: education on medications, management of symptoms, instructions on tracking weight and self-adjusting diuretic doses. Control group: usual care. Medication adherence assessed in all patients.	2-min walk test, quality of life, knowledge of drug therapy and medication adherence, hospital admissions, and ED visits	Intervention group: improved adherence, exercise capacity, and knowledge of drug therapy. Intervention group had more ED visits and calls to physicians but fewer hospital admissions and lower overall costs. Quality of life did not differ between groups.	Intervention group seen every 3 mo. Twelve-mo study duration.
Murray et al.[59]	RCT. n=314. Pharmacist-directed medication adherence assessment/ intervention. HF patients with a low health literacy level. Determine adherence barriers and tailor medication education. Control group: usual care within cardiology clinic.	Medication adherence and clinical exacerbations (ED visits/hospitalization)	Medication adherence improved: 67% control vs 79% intervention group; ED visits and hospitalizations reduced by 19.4% in intervention group vs control (IRR 0.82, CI 0.73–0.93)	Adherence tracked by electronic monitoring device. Adherence effect dissipated once patients no longer in direct contact with pharmacist.
Holland et al.[95]	RCT. n=273. Admission or ED visit for HF. Intervention: home visit by community pharmacist within 2 wk of discharge. Medication education, basic exercise, dietary, and smoking cessation, tracking signs and symptoms of HF.	All-cause ED visits and hospitalizations over 6 mo	*No* differences in hospital readmissions, adherence, or quality of life scores	Pharmacist educators were not specialists in HF, which could have affected the consistency of interventions.
Roughead et al.[96]	Cohort study. HF patients > 65 yr taking BB. Exposed (n=273): physician/ pharmacist team; home medicines review by pharmacist; report by pharmacist to physician who then designed medication management plan and communicated the plan to the patient. Compared to unexposed control: n=5444.	Time to first hospitalization	Time to first hospitalization significantly delayed in exposed group; 45% reduction in rate of hospitalization for HF (HR 0.55; 95% CI 0.39–0.77)	Exposed group had more comorbidities, were taking more prescriptions, and had higher rates of hospitalization before the study.

BB = beta-blocker; other abbreviations as in Table 3.

Table 5. Heart Transplant Pharmacist Responsibilities/Standards

Responsibilities/Standards	Source of Standard
Preoperative phase	
Recipient evaluation, education, and documentation of visit	AST
Perioperative phase	
Evaluates, identifies, and solves medication related problems for transplant recipients	UNOS, AST
Educates transplant recipients and their family members on transplant medications and adherence to medication regimen; documentation of visit	UNOS, AST
Acts as a liaison (advocate) between patient and patients' families and other health care team members regarding medication issues	UNOS
Prepares and assists with discharge planning for all transplant recipients; documentation of discharge medication	UNOS, AST
Provides drug information and training for all members and trainees of the transplant team	UNOS, AST
Posttransplantation phase	
Attends daily rounds with prospective evaluation of individual pharmacotherapy	AST
Communicates all transplant recipient medication issues and concerns to appropriate members of the transplant team	UNOS
Assists with designing, implementing, and monitoring of comprehensive care plans with other team members	UNOS
Coordinates development and implementation of drug therapy protocols, assists in protocol adherence, and measures associated outcomes	AST
Facilitates cost-containment strategies and pharmacotherapy optimization	AST
Quality assurance of medication regimens	UNOS
Clinical research studies	UNOS
Public and professional education	UNOS

UNOS = United Network for Organ Sharing bylaws; AST = American Society of Transplantation standards.
Adapted from references 100 and 101.

for transplant candidates and communicate recommendations to the transplant selection committee. These may include financial barriers as well as health literacy barriers. Clinical pharmacists may also participate in developing and monitoring sensitization protocols for heart transplant candidates.

Posttransplantation Phase

After heart transplantation, the medication burden for a patient may actually be larger than before surgery. With an average intake of 10 drugs per day, the medication regimen may be difficult to integrate into a recipient's daily life.[108] Pharmacotherapy generally consists of: (i) immunosuppressive medications with at least twice/day dosing and numerous side effects; (ii) antimicrobials, including prophylactic regimens; (iii) treatment of associated comorbidities such as diabetes, gout, dyslipidemia, renal dysfunction, hypertension, and osteoporosis/osteopenia; and (iv) non-transplant–related medications for pretransplantation conditions, such as hypothyroidism or pulmonary disease.[109, 110]

Drug–drug interactions also are a concern. The risk for both pharmacokinetic and pharmacodynamic drug–drug interactions is exacerbated by advanced age, polypharmacy, comorbidities, medications with a narrow therapeutic index, or medications requiring intensive monitoring. With the exception of advanced age, each of these is present in the heart transplant recipient.[98] Additionally, the cytochrome P450 3A enzyme system, which is responsible for the biotransformation of calcineurin inhibitors and mammalian target of rapamycin inhibitors, is an important metabolic pathway for 60% of drugs that undergo oxidation.[98] P-Glycoprotein can also be altered, leading to changes in concentrations of immunosuppressants or other medications. Because not all drug–drug interactions are reported in the literature, providers must be able to predict potential interactions based on medication clearance or side effect profile.

Immunosuppressants are critical to the success of the allograft. Unfortunately, those medications also possess many side effects, including increased susceptibility to several types of infections and potential for renal dysfunction, which remain major causes of morbidity and mortality.[111] Clinical pharmacists help to ensure proper infection treatment and prophylaxis through appropriate antimicrobial selection based on cultures and sensitivities, optimized dosing based on renal or hepatic function, and TDM for potential toxicities. In addition, many

antimicrobials, particularly antifungals, macrolides, and newer-generation antibiotics, have significant interactions with immunosuppressive agents via the cytochrome P450 system that may require dose adjustment or monitoring. Clinical pharmacists are also well equipped to recommend alternate antimicrobial therapies in cases of earlier or current allergic reactions and cost limitations.

With considerable regimen complexity, medication nonadherence with immunosuppressant medications has been estimated to be as high as 20% during the first year after transplantation and 16% thereafter.[108, 112] Medication nonadherence in the first year after heart transplantation or > 1 year after transplantation appears to be an independent risk factor for acute rejection episodes and transplant coronary artery disease within 3–5 years after transplantation.[113, 114]

One of the most significant concerns for transplant patients is the cost of medications. Although many transplant recipients have prescription medication insurance, such as Medicare (which pays for immunosuppressive medications) or commercial insurance, a substantial number of patients do not.[115] Moreover, Medicare covers only 80% of the cost of immunosuppressive therapy, and the remaining 20% may cost up to $2000–$3000 annually. The use of generic immunosuppressive drugs is an issue directly related to the cost and availability of prescription medications for transplant recipients. Because immunosuppressants represent a class of drugs with a narrow therapeutic index, the transplant community has been faced with the challenge of whether to adopt generic substitutions. Clinical pharmacists play an important role in helping the patient remain on branded medication if necessary through education and navigation of filling and refilling prescriptions in pharmacies, or alternatively they may help patients safely switch to generic medications if appropriate.[116] It is important for pharmacists to educate their patients to monitor the appearance of their medications and inquire with the pharmacy if a generic substitution has occurred. Additionally, the patient should also inform the transplant team in the event of a substitution. Transplant centers vary in their tolerance of the use of generic immunosuppressants; if such use is acceptable, the pharmacist can help to assess the patient for potential adverse effects and advocate for closer monitoring.

Evidence to Support the Value of Pharmacists on the Transplant Team

The value of clinical pharmacy services has been documented in several randomized controlled trials in renal transplant recipients.[117-121] In those studies, the pharmacy intervention consisted of reviewing medication histories with an emphasis on medication therapy as well as minimization of drug–drug interactions, encouraging medication adherence, increasing access to medication assistance programs, and providing recommendations to members of the transplant team regarding desired health outcomes through medication therapy management. Compared with those who did not, those who did receive clinical pharmacist interventions had a significantly higher mean rate of medication adherence (defined as taking $\geq$80% of prescribed daily doses), were adherent longer, and had improved control of comorbid conditions.[117–121]

Additional Activities of the Clinical Pharmacist Practicing in Heart Failure

Role as Educators

Clinical pharmacists are frequently involved in educational venues such as grand rounds, patient working rounds, and/or focused in-services. All medical disciplines at all levels are likely to benefit from education about pharmacokinetics and pharmacodynamics. Several national and international cardiology and transplant organizations include clinical pharmacists as active members, providing expertise on pharmacology and pharmacotherapy for specialized educational meeting symposia, white papers, and practice guidelines.

Research

The clinical pharmacist provides important contributions to both sponsored and investigator-initiated research. Many clinical pharmacists are independent researchers, conducting investigator-initiated research and contributing important scientific advances to the field. For sponsored research, clinical pharmacists may be contracted to serve as a site principal investigator or to participate in the randomization of patients, dispensing of therapy, and other operational aspects of the study. Many clinical pharmacists have access to medication databases

which could be used to generate preliminary data or to conduct retrospective studies. Finally, clinical pharmacists serve as collaborators for translational research, teaming with other researchers and/or clinicians to investigate certain hypotheses with the use of in vitro or animal models. Regardless of the type of research being performed, the addition of a clinical pharmacist to the team enhances research opportunities and therefore such alliances are encouraged.

Multidisciplinary Committees and Organizations

At the programmatic level, there are several support committees, teams, working groups, and task forces that rely on multidisciplinary involvement, including that from clinical pharmacists, for their operations. Individual units within a health care system may run quality assurance and performance improvement (QAPI) committees for their population. Likewise, heart transplant and MCS programs often use those QAPI forums to improve their workings and outcomes within the system. Clinical pharmacists may contribute important information regarding medication adherence to transplant selection committees.

Training Requirements for Clinical Pharmacists Participating on Heart Failure Teams

As with medicine and nursing, clinical pharmacists can obtain advanced training through the completion of residencies and/or fellowships with a specialty focus in critical care, cardiology, transplantation, or ambulatory care.[122] Additionally, pharmacists can document recognition of their clinical knowledge through obtaining board certification.[123]

The Doctor of Pharmacy (PharmD) is currently the entry-level degree for all pharmacy students in United States colleges and schools of pharmacy.[124] On successful completion of the PharmD degree and the licensure process, pharmacists are eligible to practice pharmacy in many settings. Similar to medical training, practice as a clinical pharmacist often requires postdoctoral training by employers. Clinical pharmacists who desire to become part of a multidisciplinary HF team are strongly encouraged to complete a minimum of postgraduate year (PGY) 1 residency in pharmacy and PGY2 residency in one of the following areas of specialty: cardiology, critical care, solid organ transplant, or ambulatory care. For more information regarding postdoctoral residency programs, regulations, and standards, refer to the American Society of Health System Pharmacists residency accreditation website.[125] An alternate track for postdoctoral specialization for clinical pharmacists is completion of a research fellowship in a particular specialty area (e.g., cardiology, critical care, transplant), often combined with a graduate degree program (e.g., Master of Public Health, Master of Science, or Doctor of Philosophy). Clinical pharmacists who choose this path more commonly pursue academic careers in pharmacy research but may also choose to practice clinically in a specialty area, such as cardiology or HF.

Although it is not presently required to practice clinical pharmacy, pharmacists may seek credentialing in the form of board certification similar to medicine. The Board of Pharmaceutical Specialties offers certification in several specialties, including pharmacotherapy (BCPS), ambulatory care (BCACP), and nutrition support (BCNSP). In addition, clinical pharmacists who are board certified in pharmacotherapy may apply for Added Qualifications in Cardiology (AQ Card).

Recognizing the varied educational backgrounds, postdoctoral training options, and credentialing of clinical pharmacists, the SCCM and ACCP Task Force on Critical Care Pharmacy Services suggested that obtaining qualifications and competence to practice in the critical care setting may be "achieved in a variety of ways, including advanced degrees, residencies, fellowships, or other specialized practice experience."[61] The same approach is encouraged for clinical pharmacists participating in the HF team.

Collaborative Practice Agreements

Over the past 10 years, collaborative practice agreements between clinical pharmacists and physicians have become more formalized. Most state boards of pharmacy provide some avenue for clinical pharmacists to adjust medications under protocol as a member of a health care team. These collaborative practice agreements are intended to have clinical pharmacists augment the efforts of a health care team with expertise in drug therapy management. Once a clinician diagnoses the condition, clinical pharmacists can assist in management of drug therapy regarding that diagnosis. Common

examples of collaborative practice agreements are in anticoagulation or pharmacokinetic dosing services, where clinical pharmacists are appropriately trained to make adjustments in warfarin, heparin, vancomycin, or aminoglycoside therapy based on clinical parameters and laboratory values.[4] The United States Public Health Service recently published a report to the Surgeon General endorsing clinical pharmacists practicing under collaborative practice agreements, citing improvements in quality outcomes in HF, diabetes, and dyslipidemia, improved access to care, and cost reductions.[126] Collaborative practice agreements within a HF/heart transplant team could include renal dosing adjustment of specific medications, adjusting and/or monitoring anticoagulation protocols for MCS patients, ACE inhibitor, beta-blocker, or diuretic titration, and appropriate laboratory monitoring in a clinic or via telephone. Each state has some variability in the practice of pharmacy statutes and rules regarding collaborative practice agreements, and some states have different requirements for inpatient and outpatient settings.

The Veterans Affairs (VA) Healthcare System and Indian Health Service have well established roles of clinical pharmacists with a scope-of-practice agreement. These agreements allow the clinical pharmacist to initiate and adjust certain drug therapies, order appropriate laboratory monitoring tests, formulate clinical assessments and plans, and change therapy based on patient response and/or the monitoring results.[126] The scope-of-practice agreements are similar to those of other nonphysician providers in that they are supervised by a managing physician, but they are generally more narrow, limited to a few specific disease states where the clinical pharmacist has the greatest expertise. Several VA Medical Centers have clinical pharmacists in cardiology and/or HF who have scopes of practice that include antihypertensive and HF medications, and centers managing organ transplant recipients have clinical pharmacists with scope-of-practice agreements that include immunosuppressive agents. The VA requirements for clinical pharmacists having scope-of-practice agreements include advanced education, including board certification and/or completion of additional training beyond initial graduation level, a peer review process, and periodic review and renewal of these agreements with the managing physician(s).

Billing for Clinical Pharmacy Services

In 2003, the United States Congress passed, and the President signed, the Medicare Modernization Act, which authorized a prescription benefit under Medicare (commonly known as "Medicare Part D"). In addition to this benefit, it introduced authorization of payment for medication therapy management (MTM) to health care professionals who provide medication evaluation and education to Medicare beneficiaries. Basic elements of the MTM process include: (i) customized patient-centered delivery of service; (ii) assessment of the patient's medication needs, drug-related problems, and a documented care plan to address them; (iii) comprehensive care addressing all medications; (iv) improvement of medication adherence; and (v) coordination with other team members providing care.[127–130] Patients who would derive the greatest benefit from MTM services include those who have not achieved a target goal of therapy, who have difficulty understanding or following their prescribed medication regimen, who may be experiencing adverse effects to medications, or who have frequent readmissions.[129, 131, 132]

In 2005, Current Procedural Terminology codes were created for MTM to allow pharmacists to submit billing for these activities, generating revenue for the activity from both third-party and Medicare Part D plans.[132–135] Provisions of MTM were strengthened in the Affordable Care Act of 2010, which not only specified pharmacists as eligible providers of MTM, but also focused on a patient-centered team approach to health care.[136] The Affordable Care Act recognizes medication reconciliation and transitions of care as areas where MTM can and should be provided. Although clinical pharmacists are not specifically recognized as obligatory members of a patient-centered medical home team (directed by a physician and including other health care professionals), the emphasis on demonstrating quality, outcomes, and patient-perceived value of care suggests that MTM would be a logical component that could be efficiently performed by a clinical pharmacist.[136] Financial resources to support clinical pharmacist activities within an HF team may originate from a variety of sources (Table 6).

Conclusion

Heart failure management and transplantation have long histories of successful multidisciplin-

Table 6. Sources of Funding to Support Clinical Pharmacists

Source of Funding	Collaborative Relationships	Clinical Pharmacist Activities
Academic	Nontenured or tenured faculty at college of pharmacy, nursing, and/or medicine	Education of students in clinical rotations, classroom teaching, support to advanced-practice nursing and medicine residency/fellowship training programs
Institutional	Department of medicine/cardiology/ transplant/quality improvement	Support efforts to improve documentation in meeting core measures
		Document overall cost savings or quality of care by clinical pharmacy services interventions (e.g., efforts to reduce readmissions, prevent adverse drug effects)—accountable care organizations
		Generate revenue by reimbursement of MTM activities (outpatient)
		Meet CMS requirement for a transplant pharmacy specialist supporting advanced HF/transplant program
Research	Faculty at colleges of medicine, pharmacy, nursing; pharmacy and medical residency and fellowship programs	NIH and non-NIH grant funding sources
		Benchtop, translational, and clinical research with funding from various independent or academic foundations
		Work closely with or function as study coordinator or investigational pharmacist for industry-supported research
Departmental	Department of pharmacy	Participate in education of staff pharmacists or pharmacy residents and fellows
		Medication use evaluation activities

CMS = Centers for Medicare and Medicaid Services; MTM = Medication therapy management; NIH = National Institutes of Health.

ary team strategies for collaboration. Multidisciplinary interventions including clinical pharmacists on inpatient, outpatient, and MCS/transplant teams have demonstrated value by improving adherence to performance measures and evidence-based drug therapies, decreasing readmission rates, identifying and preventing adverse drug events and interactions, assessing and providing solutions for barriers to medication access, improving medication adherence, and decreasing costs. Clinical pharmacists may also contribute to education of other team members and students, serve on quality and performance-improvement committees, and be active members of research teams. Clinical pharmacists may supplement the activities of other team members, such as nurses, physician assistants, and nurse practitioners, by focusing on medication-related patient education topics. Medication reconciliation and education are critical factors in transitions of care, and clinical pharmacists are well suited for these activities. Mechanisms exist for MTM services provided by clinical pharmacists to garner reimbursement from CMS and other third-party payers. Partnerships between institutions or health systems and colleges of pharmacy for training of pharmacy students and residents may also provide financial support for clinical pharmacists. These data support a clinical pharmacist as an important member of a multidisciplinary HF team.

References

1. **Hepler CD, Strand LM.** Opportunities and responsibilities in pharmaceutical care. Am J Hosp Pharm 1990;47:533–43.
2. **Hepler CD, Strand LM.** Opportunities and responsibilities in pharmaceutical care. Am J Pharm Educ 1989;53(Suppl):7Se15S.
3. **Strand LM, Morley PC, Cipolle RJ, Ramsey R, Lamsam GD.** Drug-related problems: their structure and function. DICP 1990;24:1093–7.
4. **Bond CA, Raehl CL.** 2006 national clinical pharmacy services survey: clinical pharmacy services, collaborative drug management, medication errors, and pharmacy technology. Pharmacotherapy 2008;28:1–13.
5. **Bond CA, Raehl CL.** Adverse drug reactions in United States hospitals. Pharmacotherapy 2006;26:601–8.
6. **Bond CA, Raehl CL.** Clinical pharmacy services, pharmacy staffing, and adverse drug reactions in United States hospitals. Pharmacotherapy 2006;26:735–47.
7. **Bond CA, Raehl CL.** Clinical pharmacy services, pharmacy staffing, and hospital mortality rates. Pharmacotherapy 2007;27:481–93.
8. **Bond CA, Raehl CL, Franke T.** Clinical pharmacy services, pharmacist staffing, and drug costs in United States hospitals. Pharmacotherapy 1999;19:1354–62.
9. **Bond CA, Raehl CL, Franke T.** Clinical pharmacy services, pharmacy staffing, and the total cost of care in United States hospitals. Pharmacotherapy 2000;20:609–21.
10. **Bond CA, Raehl CL, Pitterle ME, Franke T.** Health care professional staffing, hospital characteristics, and hospital mortality rates. Pharmacotherapy 1999;19:130–8.
11. **Bond CA, Raehl CL, Franke T.** Clinical pharmacy services, hospital pharmacy staffing, and medication errors in United States hospitals. Pharmacotherapy 2002;22:134–47.
12. **Bond CA, Raehl CL, Franke T.** Medication errors in United States hospitals. Pharmacotherapy 2001;21:1023–36.
13. **Geber J, Parra D, Beckey NP, Korman L.** Optimizing drug therapy in patients with cardiovascular disease: the impact of pharmacist- managed pharmacotherapy clinics in a primary care setting. Pharmacotherapy 2002;22:738–47.
14. **McConnell KJ, Humphries TL, Raebel MA, Merenich JA, Clinical Pharmacy Cardiac Risk Service Study Group.** Clini-

cal pharmacy specialist implementation of lisinopril therapy in patients with coronary artery disease and diabetes mellitus. Pharmacotherapy 2003;23:1564–72.
15. **Ellis SL, Carter BL, Malone DC, et al.** Clinical and economic impact of ambulatory care clinical pharmacists in management of dyslipidemia in older adults: the IMPROVE study. Pharmacotherapy 2000;20:1508–16.
16. **Bex SD, Boldt AS, Needham SB, et al.** Effectiveness of a hypertension care management program provided by clinical pharmacists for veterans. Pharmacotherapy 2011;31:31–8.
17. **Padiyara RS, d'Souza JJ, Rihani RS.** Clinical pharmacist intervention and the proportion of diabetes patients attaining prevention objectives in a multispecialty medical group. J Manag Care Pharm 2011;17:456–62.
18. **Lee JK, Grace KA, Taylor AJ.** Effect of a pharmacy care program on medication adherence and persistence, blood pressure, and low- density lipoprotein cholesterol: a randomized controlled trial. JAMA 2006;296:2563–71.
19. **Monte SV, Slazak EM, Albanese NP, Adelman M, Rao G, Paladino JA.** Clinical and economic impact of a diabetes clinical pharmacy service program in a university and primary care-based collaboration model. J Am Pharm Assoc 2009;49:200–8.
20. **Rich MW, Beckham V, Wittenberg C, Leven CL, Freedland KE, Carney RM.** A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. N Engl J Med 1995;333:1190–5.
21. **Stewart S, Pearson S, Horowitz JD.** Effects of a home-based intervention among patients with congestive heart failure discharged from acute hospital care. Arch Intern Med 1998;158:1067–72.
22. **Fonarow GC, Stevenson LW, Walden JA, et al.** Impact of a comprehensive heart failure management program on hospital readmission and functional status of patients with advanced heart failure. J Am Coll Cardiol 1997;30:725–32.
23. **Riegel B, Thomason T, Carlson B, et al.** Implementation of a multidisciplinary disease management program for heart failure patients. Congest Heart Fail 1999;5:164–70.
24. **Costantini O, Huck K, Carlson MD, et al.** Impact of a guideline-based disease management team on outcomes of hospitalized patients with congestive heart failure. Arch Intern Med 2001;161:177–82.
25. **Lloyd-Jones D, Adams R, Carnethon M, et al.** Heart disease and stroke statisticsd—2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation 2009;119:e21–181.
26. **Krumholz HM, Parent EM, Tu N, et al.** Readmission after hospitalization for congestive heart failure among Medicare beneficiaries. Arch Intern Med 1997;157:99–104.
27. **Kongkaew C, Noyce PR, Ashcroft DM.** Hospital admissions associated with adverse drug reactions: a systematic review of prospective observational studies. DICP 2008;42:1017–25.
28. **McDonnell PJ, Jacobs MR.** Hospital admissions resulting from preventable adverse drug reactions. DICP 2002;36:1331–6.
29. **Jha AK, Kuperman GJ, Rittenberg E, Teich JM, Bates DW.** Identifying hospital admissions due to adverse drug events using a computer- based monitor. Pharmacoepidemiol Drug Saf 2001;10:113–9.
30. **Leape LL, Cullen DJ, Clapp MD, et al.** Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. JAMA 1999;282:267–70.
31. **Kane SL, Weber RJ, Dasta JF.** The impact of critical care pharmacists on enhancing patient outcomes. Intensive Care Med 2003;29:691–8.
32. **LaPointe NM, Jollis JG.** Medication errors in hospitalized cardiovascular patients. Arch Intern Med 2003;163:1461–6.
33. **Murray MD, Ritchey ME, Wu J, Tu W.** Effect of a pharmacist on adverse drug events and medication errors in outpatients with cardiovascular disease. Arch Intern Med 2009;169:757–63.
34. **Masoudi FA, Baillie CA, Wang Y, Bradford WD, Steiner JF, Havranek EP.** The complexity and cost of drug regimens of older patients hospitalized with heart failure in the United States, 1998–2001. Arch Intern Med 2005;165:2069–76.
35. **Wong CY, Chaudhry SI, Desai MM, Krumholz HM.** Trends in comorbidity, disability, and polypharmacy in heart failure. Am J Med 2011;124:136–43.
36. **Juurlink DN, Mamdani MM, Lee DS, et al.** Rates of hyperkalemia after publication of the Randomized Aldactone Evaluation Study. N Engl J Med 2004;351:543–51.
37. **Pitt B, Zannad F, Remme WJ, et al.** The effect of spironolactone on morbidity and mortality in patients with severe heart failure. Randomized Aldactone Evaluation Study Investigators. N Engl J Med 1999;341:709–17.
38. **Talatinian A, Chow SL, Heywood JT.** Mineralocorticoid receptor antagonists: an expanding role in heart failure. Pharmacotherapy 2012;32:827–37.
39. **Koppel R, Metlay JP, Cohen A, et al.** Role of computerized physician order entry systems in facilitating medication errors. JAMA 2005;293:1197–203.
40. **Zhan C, Hicks RW, Blanchette CM, Keyes MA, Cousins DD.** Potential benefits and problems with computerized prescriber order entry: analysis of a voluntary medication error-reporting database. Am J Hosp Pharm 2006;63:353–8.
41. **Gerbino PP.** Digitalis glycoside intoxicationda preventive role for pharmacists. Am J Hosp Pharm 1973;30:499–504.
42. **Tisdale JE, Wroblewski HA, Overholser BR, Kingery JR, Trujillo TN, Kovacs RJ.** Prevalence of QT interval prolongation in patients admitted to cardiac care units and frequency of subsequent administration of qt interval-prolonging drugs: a prospective, observational study in a large urban academic medical center in the US. Drug Saf 2012;35:459–70.
43. **Joint Commission.** National patient safety goals 2011. Available from http://www.jointcommission.org/standards_information/npsgs.aspx. Accessed May 31, 2012.
44. **Bobb A, Gleason K, Husch M, Feinglass J, Yarnold PR, Noskin GA.** The epidemiology of prescribing errors: the potential impact of computerized prescriber order entry. Arch Intern Med 2004;164:785–92.
45. **Gleason KM, Groszek JM, Sullivan C, Rooney D, Barnard C, Noskin GA.** Reconciliation of discrepancies in medication histories and admission orders of newly hospitalized patients. Am J Health Syst Pharm 2004;61:1689–95.
46. **Bergkvist A, Midlov P, Hoglund P, Larsson L, Bondesson A, Eriksson T.** Improved quality in the hospital discharge summary reduces medication errorsd—LIMM: Landskrona Integrated Medicines Management. Eur J Clin Pharmacol 2009;65:1037–46.
47. **Hayes BD, Donovan JL, Smith BS, Hartman CA.** Pharmacist-conducted medication reconciliation in an emergency department. Am J Health Syst Pharm 2007;64:1720–3.
48. **Murphy EM, Oxencis CJ, Klauck JA, Meyer DA, Zimmerman JM.** Medication reconciliation at an academic medical center: implementation of a comprehensive program from admission to discharge. Am J Health Syst Pharm 2009;66:2126–31.
49. **Pippins JR, Gandhi TK, Hamann C, et al.** Classifying and predicting errors of inpatient medication reconciliation. J Gen Intern Med 2008;23:1414–22.
50. **Steurbaut S, Leemans L, Leysen T, et al.** Medication history reconciliation by clinical pharmacists in elderly inpatients admitted from home or a nursing home. DICP 2010;44:1596–603.
51. **Varkey P, Cunningham J, O'Meara J, Bonacci R, Desai N, Sheeler R.** Multidisciplinary approach to inpatient medication reconciliation in an academic setting. Am J Health Syst Pharm 2007;64:850–4.
52. **Eggink RN, Lenderink AW, Widdershoven JW, van den Bemt PM.** The effect of a clinical pharmacist discharge service on medication discrepancies in patients with heart failure. Pharm World Sci 2010;32:759–66.
53. **Gwadry-Sridhar FH, Arnold JM, Zhang Y, Brown JE, Marchiori G, Guyatt G.** Pilot study to determine the impact of a

multidisciplinary educational intervention in patients hospitalized with heart failure. Am Heart J 2005;150:982.e1–9.
54. **LaForest S, Gee J, Pugacz A, et al.** SERIOUS medication reconciliation clinic: improving transitions in care. J Card Fail 2010;16(8 Suppl):s112m. [abstract].
55. **Boockvar KS, Carlson LaCorte H, Giambanco V, Fridman B, Siu A.** Medication reconciliation for reducing drug-discrepancy adverse events. Am J Geriatr Pharmacother 2006;4:236–43.
56. **Walker PC, Bernstein SJ, Jones JN, et al.** Impact of a pharmacist-facilitated hospital discharge program: a quasi-experimental study. Arch Intern Med 2009;169:2003–10.
57. **Ambardekar AV, Fonarow GC, Hernandez AF, Pan W, Yancy CW, Krantz MJ.** Characteristics and in-hospital outcomes for nonadherent patients with heart failure: findings from Get With the Guidelinese Heart Failure (GWTG-HF). Am Heart J 2009;158:644–52.
58. **Bagchi AD, Esposito D, Kim M, Verdier J, Bencio D.** Utilization of, and adherence to, drug therapy among medicaid beneficiaries with congestive heart failure. Clin Ther 2007;29:1771–83.
59. **Murray MD, Young J, Hoke S, et al.** Pharmacist intervention to improve medication adherence in heart failure: a randomized trial. Ann Intern Med 2007;146:714–25.
60. **Chisholm MA, DiPiro JT.** Pharmaceutical manufacturer assistance programs. Arch Intern Med 2002;162:780–4.
61. **Rudis MI, Brandl KM.** Society of Critical Care Medicine and American College of Clinical Pharmacy Task Force on Critical Care Pharmacy Services. Position paper on critical care pharmacy services. Crit Care Med 2000;28:3746–50.
62. **Brilli RJ, Spevetz A, Branson RD, et al.** Critical care delivery in the intensive care unit: defining clinical roles and the best practice model. Crit Care Med 2001;29:2007–19.
63. **Murray MD.** Implementing pharmacy practice research programs for the management of heart failure. Pharm World Sci 2010;32:546–8.
64. **Peterson ED, Albert NM, Amin A, Patterson JH, Fonarow GC.** Implementing critical pathways and a multidisciplinary team approach to cardiovascular disease management. Am J Cardiol 2008;102(5A):47Ge56G.
65. **White CM.** Ensuring that patients receive full cardiac pharmacotherapy services: a pharmacist's call to arms. DICP 2006;40:2248–50.
66. **White C, Chow M.** Cost impact and clinical benefits of focused rounding in the cardiovascular intensive care unit. Hosp Pharm 1998;33:419–23.
67. **Gandhi PJ, Smith BS, Tataronis GR, Maas B.** Impact of a pharmacist on drug costs in a coronary care unit. Am J Health Syst Pharm 2001;58:497–503.
68. **Joint Commission.** Core measure sets: heart failure 2011. Available from http://www.jointcommission.org/core_measure_sets.aspx. Accessed June 9, 2012.
69. **ADHERE (Acute Decompensated Heart Failure Registry).** Q1 2006 final cumulative national benchmark report. Mountain View: Scios, 2006.
70. **Fonarow GC, Heywood JT, Heidenreich PA, Lopatin M, Yancy CW.** Temporal trends in clinical characteristics, treatments, and outcomes for heart failure hospitalizations, 2002 to 2004: findings from Acute Decompensated Heart Failure National Registry (ADHERE). Am Heart J 2007;153:1021–8.
71. **Krantz MJ, Ambardekar AV, Kaltenbach L, Hernandez AF, Heidenreich PA, Fonarow GC.** Patterns and predictors of evidence- based medication continuation among hospitalized heart failure patients (from Get With the GuidelineseHeart Failure). Am J Cardiol 2011;107:1818–23.
72. **Sato N, Kajimoto K, Asai K, et al.** Acute decompensated heart failure syndromes (ATTEND) registry. A prospective observational multicenter cohort study: rationale, design, and preliminary data. Am Heart J 2010;159949–955e941.
73. **Fonarow GC, Abraham WT, Albert NM, et al.** Influence of a performance- improvement initiative on quality of care for patients hospitalized with heart failure: results of the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients With Heart Failure (OPTIMIZE-HF). Arch Intern Med 2007;167:1493–502.
74. **Fonarow GC, Abraham WT, Albert NM, et al.** Prospective evaluation of beta-blocker use at the time of hospital discharge as a heart failure performance measure: results from OPTIMIZE-HF. J Card Fail 2007;13:722–31.
75. **Atherton JJ, Hayward CS, Wan Ahmad WA, et al.** Patient characteristics from a regional multicenter database of acute decompensated heart failure in Asia Pacific (ADHERE InternationaleAsia Pacific). J Card Fail 2012;18:82–8.
76. **Kfoury AG, French TK, Horne BD, et al.** Incremental survival benefit with adherence to standardized heart failure core measures: a performance evaluation study of 2958 patients. J Card Fail 2008;14:95–102.
77. **Youn YJ, Yoo BS, Lee JW, et al.** Treatment performance measures affect clinical outcomes in patients with acute systolic heart failure: report from the Korean Heart Failure Registry. Circ J 2012;76:1151–8.
78. **Scrutinio D, Passantino A, Ricci VA, Catanzaro R.** Association between conformity with performance measures and 1-year postdischarge survival in patients with acute decompensated heart failure. Am J Med Qual 2013;28:160–8. Epub 2012 Jul 22.
79. **Rodgers JE, Stough WG.** Underutilization of evidence-based therapies in heart failure: the pharmacist's role. Pharmacotherapy 2007;27(4 Pt 2):18Se28S.
80. **Campbell PT, Tremaglio J, Bhardwaj A, Ryan J.** Utility of daily diuretic orders for identifying acute decompensated heart failure patients for quality improvement. Crit Pathw Cardiol 2010;9:148–51.
81. **Ginsburg PB.** Spending to saved ACOs and the Medicare Shared Savings Program. N Engl J Med 2011;364:2085–6.
82. **Bond CA, Raehl CL, Patry R.** Evidence-based core clinical pharmacy services in United States hospitals in 2020: services and staffing. Pharmacotherapy 2004;24:427–40.
83. **Corbelli JC, Janicke DM, Corbelli JA, Chow S, Pruski M.** Acute coronary syndrome emergency treatment strategies: a rationale and road map for critical pathway implementation. Crit Pathw Cardiol 2003;2:71–87.
84. **Coons JC, Fera T.** Multidisciplinary team for enhancing care for patients with acute myocardial infarction or heart failure. Am J Health Syst Pharm 2007;64:1274–8.
85. **Horn E, Jacobi J.** The critical care clinical pharmacist: evolution of an essential team member. Crit Care Med 2006;34(3 Suppl):S46–51.
86. **Miller RJAE, Page RL.** Discharge counseling in heart failure and myocardial infarction – a best practices model developed by the members of the American College of Clinical Pharmacy's Cardiology PRN based on the Hospital to Home (H2H) Initiative. Pharmacotherapy 2013;??????:??????–??????. In press.
87. **Koshman SL, Charrois TL, Simpson SH, McAlister FA, Tsuyuki RT.** Pharmacist care of patients with heart failure: a systematic review of randomized trials. Arch Intern Med 2008;168:687–94.
88. **Kripalani S, Roumie CL, Dalal AK, et al.** Effect of a pharmacist intervention on clinically important medication errors after hospital discharge: a randomized trial. Ann Intern Med 2012;157:1–10.
89. **Lopez Cabezas C, Salvador C, Quadrada D, et al.** Randomized clinical trial of a postdischarge pharmaceutical care program vs regular follow-up in patients with heart failure. Farm Hosp 2006;30:328–42.
90. **Tsuyuki RT, Fradette M, Johnson JA, et al.** A multicenter disease management program for hospitalized patients with heart failure. J Card Fail 2004;10:473–80.
91. **Rainville EC.** Impact of pharmacist interventions on hospital readmissions for heart failure. Am J Health Syst Pharm 1999;56:1339–42.
92. **Gattis WA, Hasselblad V, Whellan DJ, O'Connor CM.** Reduction in heart failure events by the addition of a clinical pharmacist to the heart failure management team: results of

the Pharmacist in Heart Failure Assessment Recommendation and Monitoring (PHARM) Study. Arch Intern Med 1999;159:1939–45.
93. **Lowrie R, Mair FS, Greenlaw N, et al.** Heart Failure Optimal Outcomes From Pharmacy Study I. Pharmacist intervention in primary care to improve outcomes in patients with left ventricular systolic dysfunction. Eur Heart J 2012;33:314–24.
94. **Varma S, McElnay JC, Hughes CM, Passmore AP, Varma M.** Pharmaceutical care of patients with congestive heart failure: interventions and outcomes. Pharmacotherapy 1999;19:860–9.
95. **Holland R, Brooksby I, Lenaghan E, et al.** Effectiveness of visits from community pharmacists for patients with heart failure: HeartMed randomised controlled trial. BMJ 2007;334:1098.
96. **Roughead EE, Barratt JD, Ramsay E, et al.** The effectiveness of collaborative medicine reviews in delaying time to next hospitalization for patients with heart failure in the practice setting: results of a cohort study. Circ Heart Fail 2009;2:424–8.
97. **Lindenfeld J, Miller GG, Shakar SF, et al.** Drug therapy in the heart transplant recipient: part II: immunosuppressive drugs. Circulation 2004;110:3858–65.
98. **Page RL 2nd, Miller GG, Lindenfeld J.** Drug therapy in the heart transplant recipient: part IV: drug–drug interactions. Circulation 2005;111:230–9.
99. **Page RL 2nd, Mueller SW, Levi ME, Lindenfeld J.** Pharmacokinetic drug–drug interactions between calcineurin inhibitors and proliferation signal inhibitors with antimicrobial agents: implications for therapeutic drug monitoring. J Heart Lung Transplant 2011;30:124–35.
100. **Alloway RR, Dupuis R, Gabardi S, et al.** Evolution of the role of the transplant pharmacist on the multidisciplinary transplant team. Am J Transplant 2011;11:1576–83.
101. **Organ Procurement and Transplant Network.** Attachement I to appendix B of the OPTN bylaws: XI. Clinical transplant pharmacist 2009. Available from http://optn.transplant.hrsa.gov/policiesandBylaws2/bylaws/OPTNByLaws/pdfs/bylaw_162.pdf. Accessed June 1, 2012.
102. **Centers for Medicare and Medicaid Services.** 42 CFR parts 405, 482, 488, and 498 Medicare program; hospital conditions of participation: requirements for approval and reapproval of transplant centers to perform organ transplants; final rule 2007. Available from https://www.cms.gov/CertificationandComplianc/Downloads/Transplantfinal.pdf. Accessed June 1, 2012.
103. **Ensor CR, Paciullo CA, Cahoon WD Jr, Nolan PE Jr.** Pharmacotherapy for mechanical circulatory support: a comprehensive review. DICP 2011;45:60–77.
104. **Rose EA, Gelijns AC, Moskowitz AJ, et al.** Long-term use of a left ventricular assist device for end-stage heart failure. N Engl J Med 2001;345:1435–43.
105. **Slaughter MS, Pagani FD, Rogers JG, et al.** Clinical management of continuous-flow left ventricular assist devices in advanced heart failure. J Heart Lung Transplant 2010;29(4 Suppl):S1–39.
106. **Slaughter MS, Rogers JG, Milano CA, et al.** Advanced heart failure treated with continuous- flow left ventricular assist device. N Engl J Med 2009;361:2241–51.
107. **Ensor CR, Cahoon WD, Crouch MA, et al.** Antithrombotic therapy for the CardioWest temporary total artificial heart. Tex Heart Inst J 2010;37:149–58.
108. **Korb-Savoldelli V, Sabatier B, Gillaizeau F, et al.** Nonadherence with drug treatment after heart or lung transplantation in adults: a systematic review. Patient Educ Couns 2010;81:148–54.
109. **Costanzo MR, Dipchand A, Starling R, et al.** The International Society of Heart and Lung Transplantation guidelines for the care of heart transplant recipients. J Heart Lung Transplant 2010;29:914–56.
110. **Lindenfeld J, Page RL 2nd, Zolty R, et al.** Drug therapy in the heart transplant recipient: part III: common medical problems. Circulation 2005;111:113–7.
111. **Snydman DR.** Infection in solid organ transplantation. Transpl Infect Dis 1999;1:21–8.
112. **de Geest S, Dobbels F, Fluri C, Paris W, Troosters T.** Adherence to the therapeutic regimen in heart, lung, and heart-lung transplant recipients. J Cardiovasc Nurs 2005;20(5 Suppl):S88–98.
113. **Dew MA, Kormos RL, Roth LH, Murali S, DiMartini A, Griffith BP.** Early post-transplant medical compliance and mental health predict physical morbidity and mortality one to three years after heart transplantation. J Heart Lung Transplant 1999;18:549–62.
114. **Dobbels F, de Geest S, van Cleemput J, Droogne W, Vanhaecke J.** Effect of late medication noncompliance on outcome after heart transplantation: a 5-year follow-up. J Heart Lung Transplant 2004;23:1245–51.
115. **Chisholm M.** Increasing medication access to transplant patients. Clin Transplant 2004;18:38–48.
116. **Ensor CR, Trofe-Clark J, Gabardi S, McDevitt-Potter LM, Shullo MA.** Generic maintenance immunosuppression in solid organ transplant recipients. Pharmacotherapy 2011;31:1111–29.
117. **Chisholm-Burns MA, Spivey CA, Garrett C, McGinty H, Mulloy LL.** Impact of clinical pharmacy services on renal transplant recipients' adherence and outcomes. Patient Prefer Adherence 2008;2:287–92.
118. **O'Grady JG, Asderakis A, Bradley R, et al.** Multidisciplinary insights into optimizing adherence after solid organ transplantation. Transplantation 2010;89:627–32.
119. **Osterberg L, Blaschke T.** Adherence to medication. N Engl J Med 2005;353:487–97.
120. **Dickson VV, Riegel B.** Are we teaching what patients need to know? Building skills in heart failure self-care. Heart Lung 2009;38:253–61.
121. **Martin JE, Zavala EY.** The expanding role of the transplant pharmacist in the multidisciplinary practice of transplantation. Clin Transplant 2004;18(Suppl 12):50–4.
122. **Murphy JE, Nappi JM, Bosso JA, et al.** American College of Clinical Pharmacy's vision of the future: postgraduate pharmacy residency training as a prerequisite for direct patient care practice. Pharmacotherapy 2006;26:722–33.
123. **Saseen JJ, Grady SE, Hansen LB, et al.** Future clinical pharmacy practitioners should be board-certified specialists. Pharmacotherapy 2006;26:1816–25.
124. **Accreditation Council for Pharmacy Education.** Accreditation standards and guidelines for the professional program in pharmacy leading to the Doctor of Pharmacy degree 2011. Available from http://www.acpe-accredit.org/pdf/S2007Guidelines2.0_ChangesIdentifiedInRed.pdf. Accessed November 29, 2011.
125. **American Society of Health-System Pharmacists.** Residency accreditation 2011. Available from www.ashp.org/menu/Accreditation/ResidencyAccreditation.aspx. Accessed November 27, 2011.
126. **Giberson S, Yoder S, Lee M.** Improving patient and health system outcomes through advanced pharmacy practiceda report to the US Surgeon General. Office of the Chief Pharmacist; US Public Health Service. 2011.
127. **Pellegrino AN, Martin MT, Tilton JJ, Touchette DR.** Medication therapy management services: definitions and outcomes. Drugs 2009;69:393–406.
128. **Culhane N, Brooks A, Cohen V, et al.** Medication therapy management services: application of the core elements in ambulatory settings 2007. Available from http://www.accp.com/docs/positions/commentaries/pos_AmCare.pdf. Accessed November 29, 2011.
129. **Zarowitz BJ, Miller WA, Helling DK, Nappi J, Wells BG, Nahata MC.** Optimal medication therapy prescribing and management: meeting patients' needs in an evolving health care system. Pharmacotherapy 2010;30:350e–9e.
130. **Ramalho de Oliveira D, Brummel AR, Miller DB.** Medication therapy management: 10 years of experience in a large integrated health care system. J Manag Care Pharm 2010;16:185–95.

131. **Isetts B.** Evaluating effectiveness of the Minnesota Medication Therapy Management care program 2007. Available from http://www.dhs.state.mn.us/main/groups/business_partners/documents/pub/dhs16_140283.pdf. Accessed July 18, 2011.
132. **DaVanzo J, Dobson A, Koenig L, Brook R.** Medication therapy management services: a critical review. Prepared for the American Pharmacists Association. 2005. Available from http://www.accp.com/docs/positions/commentaries/mtms.pdf. Accessed July 9, 2011.
133. **McInnis T, Strand L, Webb C.** The patient-centered medical home: integrating comprehensive medication management to optimize patient outcomes. 2010. Available from http://www.pcpcc.net/files/medmanagepub.pdf. Accessed July 9, 2011.
134. **Snella KA, Sachdev GP.** A primer for developing pharmacist-managed clinics in the outpatient setting. Pharmacotherapy 2003;23:1153–66.
135. **Snella KA, Trewyn RR, Hansen LB, Bradberry JC.** Pharmacist compensation for cognitive services: focus on the physician office and community pharmacy. Pharmacotherapy 2004;24:372–88.
136. **Stubbings J, Nutescu E, Durley SF, Bauman JL.** Payment for clinical pharmacy services revisited. Pharmacotherapy 2011;31:1–8.