

Knowledge Gaps in Cardiovascular Care of the Older Adult Population

A Scientific Statement From the American Heart Association, American College of Cardiology, and American Geriatrics Society

Michael W. Rich, MD, FAHA, FACC, Chair; Deborah A. Chyun, PhD, RN, FAHA, Co-Chair;
Adam H. Skolnick, MD, FACC; Karen P. Alexander, MD, FAHA, FACC;
Daniel E. Forman, MD, FACC; Dalane W. Kitzman, MD, FAHA, FACC;
Mathew S. Maurer, MD, FACC; James B. McClurken, MD, FACC;
Barbara M. Resnick, PhD, CRNP; Win K. Shen, MD, FAHA, FACC;

David L. Tirschwell, MD, MSc, FAHA; on behalf of the American Heart Association Older
Populations Committee of the Council on Clinical Cardiology, Council on Cardiovascular and Stroke
Nursing, Council on Cardiovascular Surgery and Anesthesia, and Stroke Council; American College of
Cardiology; and American Geriatrics Society

Abstract—The incidence and prevalence of most cardiovascular disorders increase with age, and cardiovascular disease is the leading cause of death and major disability in adults ≥ 75 years of age; however, despite the large impact of cardiovascular disease on quality of life, morbidity, and mortality in older adults, patients aged ≥ 75 years have been markedly underrepresented in most major cardiovascular trials, and virtually all trials have excluded older patients with complex comorbidities, significant physical or cognitive disabilities, frailty, or residence in a nursing home or assisted living facility. As a result, current guidelines are unable to provide evidence-based recommendations for diagnosis and treatment of older patients typical of those encountered in routine clinical practice. The objectives of this scientific statement are to summarize current guideline recommendations as they apply to older adults, identify critical gaps in knowledge that preclude informed evidence-based decision making, and recommend future research to close existing knowledge gaps. To achieve these objectives, we conducted a detailed review of current American College of Cardiology/American Heart Association and American Stroke Association guidelines to identify content and recommendations that explicitly targeted older patients. We found that there is a pervasive lack of evidence to guide clinical decision making in older patients with cardiovascular disease, as well as a paucity of data on the impact of diagnostic and therapeutic interventions on key outcomes that are particularly important to older patients, such as quality of life, physical function, and maintenance of independence. Accordingly, there is a critical need for a multitude of large population-based studies and clinical trials that include a broad spectrum of older patients representative of those seen in clinical practice and that incorporate relevant outcomes important to older patients in the study design. The results of

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these studies will provide the foundation for future evidence-based guidelines applicable to older patients, thereby enhancing patient-centered evidence-based care of older people with cardiovascular disease in the United States and around the world. (*Circulation*. 2016;133:2103–2122. DOI: 10.1161/CIR.0000000000000380.)

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The prevalence of cardiovascular disease (CVD) increases progressively with age, and people ≥ 65 years of age account for more than half of all cardiovascular hospitalizations and procedures in the United States, as well as $\approx 80\%$ of all cardiovascular deaths.¹ Although people ≥ 75 years old account for only $\approx 6\%$ of the total population, $>50\%$ of cardiovascular deaths occur in this age group.¹ Indeed, cancer is the leading cause of death among US adults 18 to 74 years of age, and it is only after age 75 years that CVD becomes the dominant cause of mortality.^{1,2} The global burden of CVD is increasing, primarily because of the aging of the population, and men and women ≥ 80 years of age account for a disproportionate number of cardiovascular deaths.³ CVD is also a major cause of chronic disability, loss of independence, and impaired quality of life among older people.^{4,5} Despite the high prevalence, morbidity, and mortality of CVD in older adults, most randomized clinical trials have either explicitly excluded older adults or have enrolled only relatively healthy older patients with few comorbidities or functional impairments.^{6,7} As a result, the generalizability of the results of most major clinical trials to older patients, especially those >75 years of age with multimorbidity, is uncertain.^{6,8} Moreover, because of age-related changes in cardiovascular structure and function,^{9,10} coupled with changes in other organ systems, including the kidneys, liver, skeletal muscle, and brain, older patients are at increased risk for complications related to pharmacological and nonpharmacological interventions. It therefore should not be assumed that outcomes reported in clinical trials involving younger and healthier patients are applicable to older adults who have fundamental alterations in risks and potential benefits of diagnostic, therapeutic, and preventive interventions. Furthermore, few clinical trials have assessed outcomes important to older adults, such as quality of life, maintenance of independence, and physical and cognitive function.⁸ Current evidence-based practice guidelines suffer inherent gaps in providing recommendations for managing older adults with CVD, the majority of whom would not have been eligible for participation in most of the major clinical trials. The objectives of this American Heart Association (AHA) scientific statement are to summarize current guideline recommendations as they apply to older adults, identify critical gaps in knowledge that preclude informed decision making, and recommend future research to close existing knowledge gaps, thereby leading to enhanced care and outcomes for the expanding population of older adults with cardiovascular disorders.

Methods

Current American College of Cardiology (ACC)/AHA and American Stroke Association (ASA) practice guidelines

(Appendix) relevant to older adults were reviewed by at least 2 members of the writing committee. Content and recommendations that explicitly focused on older patients were identified and summarized. Pertinent gaps in knowledge that limited the applicability of guideline recommendations to older adults, especially those >75 years of age and those with multimorbidity or other complexities of care (eg, cognitive impairment, nursing home residence), were identified, and specific research recommendations for overcoming these knowledge gaps were proposed. The initial draft of the manuscript was reviewed by all members of the writing committee to identify additional knowledge gaps and research needs. The manuscript was subsequently reviewed by 16 content experts representing the ACC, AHA, and American Geriatrics Society. All comments and suggestions were addressed, and the revised manuscript was reviewed and approved by all members of the writing group before submission for publication.

Knowledge Gaps Across Guidelines

Several common themes pertaining to knowledge gaps extend across most of the ACC/AHA and ASA guidelines. In general, the studies on which the guidelines are based enrolled few older adults or included older patients with few comorbidities who were not representative of the older population treated for CVD in the community. The importance of assessing relevant domains beyond chronological age, such as frailty and cognitive function, and the incorporation of patient preferences into shared decision making have not been assessed adequately. The utility of all cardiac preventative measures, diagnostic tests, and therapeutic interventions, including medications, invasive procedures, and other programs (eg, cardiac rehabilitation) in the management of older patients with CVD warrants careful scrutiny, especially in the context of multimorbidity, polypharmacy, functional limitations, and frailty.¹¹

Recommendations to Close Knowledge Gaps Across Guidelines

- Intensive efforts are needed to recruit representative older adults in clinical cardiovascular research. There should be mandatory reporting of enrollment, assistance with transportation and other challenges that limit the inclusion of older adults, and detailed postmarketing surveillance. Studies that include the full spectrum of community-dwelling and institutionalized older adults are essential, especially in light of the marked heterogeneity of the older population. In particular, older patients with multiple comorbid conditions, functional and cognitive deficits, and frailty should be actively included in clinical studies. Studies should also address sex, racial/ethnic, and cultural issues through prespecified enrollment

criteria and subgroup analyses. Methodologies for increasing participation of older adults in clinical research should be explored (eg, US Food and Drug Administration labeling of drugs and devices as being approved or not approved for use in elderly patients).

- In addition to assessing conventional clinical outcomes, future studies should incorporate health status, quality of life, functional capacity (eg, ability to perform activities of daily living and instrumental activities of daily living), maintenance of independence, and cognitive function.
- Similarly, there is a need for studies that assess cost-effectiveness, value, and resource utilization in the diagnosis and treatment of older adults with or at risk for CVD and with reference to specific patient-centered clinical outcomes.
- Models for integration of patient preferences, values, and goals of care into the decision-making process for management of CVD in older adults are needed. Such models should also involve caregivers and significant others and must anticipate and incorporate methods for overcoming impediments to decision making, such as cognitive impairment and sensory deficits. Research is also needed to develop simple, patient-friendly tools that enable care providers to integrate patient preferences and goals of care into the decision-making process. Similarly, research is needed to better define subgroups of patients who, as a result of advanced disability, cognitive impairment, or other factors, may be unlikely to derive significant benefit from aggressive therapies and who may be better served by referral for palliative care or hospice.
- Studies are needed to develop more accurate models for assessing prognosis and life expectancy in older adults with CVD in the context of multiple chronic conditions and heterogeneous functional and cognitive status. Better tools are needed to more accurately characterize domains of health in older adults, and studies are needed to evaluate strategies for incorporating data on health status and prognosis into the decision-making process. Similarly, tools and biomarkers are needed to predict the trajectory of cognitive impairment, disability, and frailty, because these factors often influence clinical decision making.
- Additional studies are needed to delineate optimal strategies for prevention of CVD in older adults, including patient-centered blood pressure, lipid, and diabetes mellitus goals, methodologies and targets for enhancing fitness, and novel approaches to primary and secondary CVD prevention.
- Studies are needed to evaluate rehabilitation services (both traditional cardiac rehabilitation and therapies focused on strength, balance, and gait training) for optimization of clinical and functional outcomes.

Coronary Artery Disease

ST-Elevation Myocardial Infarction and Non-ST-Elevation Acute Coronary Syndromes

Current Recommendations

The “2013 ACCF/AHA Guideline for the Management of ST-Elevation Myocardial Infarction,” a revision of the 2004

ST-elevation myocardial infarction guideline and the 2007 and 2009 focused ST-elevation myocardial infarction updates, is, by design, narrow in scope to provide a focused tool for providers.^{12–15} Although it is acknowledged that older patients often present challenges for diagnosis and treatment, few recommendations advocate alterations in management in patients of advanced age.

The “2014 AHA/ACC Guideline for the Management of Patients With Non-ST-Elevation Acute Coronary Syndromes” includes a separate section that addresses management of older adults.¹⁶ Three Class I and 2 Class IIa recommendations are provided. Among these, it is noted that “management decisions for older patients with NSTEMI-ACS [non-ST-elevation acute coronary syndrome] should be patient centered, and consider patient preferences/goals, comorbidities, functional and cognitive status, and life expectancy (*Level of Evidence: B*).” The need for dosage adjustment of many medications to reduce the risk of adverse effects, such as bleeding, is acknowledged, as is the increased risk associated with revascularization procedures in older adults relative to younger patients. It is also noted that the potential benefits of aggressive treatment in older adults with NSTEMI-ACS are often equal to or greater than those in younger people, and it is emphasized that such therapies should not be withheld solely on the basis of age.

The NSTEMI-ACS guideline acknowledges that older patients present complex challenges because of atypical symptomatology, high prevalence of cardiac and noncardiac comorbidities, age-related alterations in cardiovascular anatomy and physiology, and increased risk for adverse drug events and interactions caused by polypharmacy. It is also acknowledged that older patients have been underrepresented in clinical trials and that numerous studies have documented that advanced age is associated with lower use of pharmacological and invasive therapies.^{17,18} Nonetheless, caution is required in treating older patients with medications because of alterations in drug metabolism and distribution that result from age-related changes in renal and hepatic function and alterations in body composition, especially reduced lean body mass.¹⁶

Recommendations to Close Knowledge Gaps

[Note: Recommendations marked with an asterisk (*) also apply to the section on stable ischemic heart disease, percutaneous coronary intervention, and coronary artery bypass graft surgery.]

- Studies are needed to assess the benefits, risks, intensity, and duration for pharmacological agents, including antiplatelet agents, statins, β -blockers, angiotensin-converting enzyme inhibitors, angiotensin-receptor blockers, and mineralocorticoid antagonists among older patients with acute coronary syndrome (ACS), with attention to multimorbidity and polypharmacy.*
- Additional studies are needed to define the risks and benefits of conservative versus invasive care in older patients with ACS, including the impact on quality of life, particularly in the setting of multimorbidity, frailty, or limited life expectancy.*
- There is a need for risk-stratification tools relevant to older adults to identify patients most likely to derive benefit from aggressive interventions.*

- Studies that assess age-associated alterations in platelet function and hemostasis are needed. Comparative effectiveness studies are needed to assess the benefits and risks of different antiplatelet agents, alone and in combination with warfarin or other antithrombotic agents, in older patients with ACS.*
- Comparative effectiveness studies are needed to assess the benefits and risks associated with drug-eluting stents versus bare-metal stents for primary percutaneous coronary intervention (PCI) in older patients with ACS, including the impact on long-term outcomes (given the need for longer dual-antiplatelet therapy with drug-eluting stents).*
- Studies are needed to assess the use of newer high-sensitivity troponin assays in older patients, including identification of appropriate diagnostic cut points and the comparative effectiveness of high-sensitivity assays versus conventional assays in the diagnosis, management, and outcomes of older patients with suspected ACS.
- Studies are needed to better clarify the appropriate management and subsequent prognosis of patients with type 2 myocardial infarction (ie, elevation of cardiac biomarkers caused by imbalance in myocardial oxygen supply and demand related to noncoronary illness, such as stress of surgery or poorly controlled hypertension), because older patients constitute a large proportion of this population.
- Studies are needed to identify and implement optimal bleeding reduction strategies in older patients.*
- Studies are needed to understand delays in presentation among older adults and to develop strategies for reducing presentation and treatment delays, including education of family and caregivers.*

Stable Ischemic Heart Disease, PCI, and Coronary Artery Bypass Graft Surgery

Current Recommendations

The “2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the Diagnosis and Management of Patients With Stable Ischemic Heart Disease” includes a section that focuses on management of patients with advanced age (section 5.12.2).¹⁹ This section notes that older adults have a high prevalence of 3-vessel and left main disease and that ischemic heart disease (IHD) is a prominent source of morbidity and mortality. The guideline highlights the limitations of exercise stress testing in older patients and endorses pharmacological testing as a more useful option for diagnosis and prognosis in many older patients.

The guideline acknowledges that although there is strong rationale to treat IHD in older adults, there are limited data pertaining to older patients, and most recommendations are inferred from studies in younger patients. Guideline-directed medical therapy is recommended as the initial approach for most patients with stable IHD, including the elderly. Revascularization is reasonable and appropriate in selected patients but should be undertaken only after due consideration of patient preferences, functional capacity, quality of life, and end-of-life issues (ie, factors that often impact clinical decision making in older patients).

Current guidelines for PCI include a single paragraph devoted to older patients, in which it is noted that the number

of patients ≥ 75 years of age undergoing PCI has increased markedly over the past 25 to 30 years.²⁰ It is pointed out that older patients present with a substantially higher clinical risk profile than younger patients and that advanced age is one of the strongest predictors of mortality after PCI.^{21,22} Older patients are also at increased risk for major bleeding and stroke.²³ However, despite increased risks, angiographic success rates and clinical benefits are similar in older and younger patients, and there is evidence that the absolute benefit may be greater in older patients because of higher baseline risk.²⁴

The “2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery” discusses issues pertaining to older adults in section 6.1 under “Specific Patient Subsets.”²⁵ It is acknowledged that compared with younger people, patients ≥ 80 years of age undergoing coronary artery bypass graft surgery (CABG) are more likely to have greater extent and severity of coronary artery disease, left ventricular dysfunction, concomitant valve disease, and prior cardiac surgery. In addition, older patients are more likely to have comorbid lung disease, peripheral arterial disease, renal insufficiency, diabetes mellitus, and hypertension. Hematologic and hepatic disorders are also more prevalent and are not accounted for in the 2 most widely used cardiac surgical risk scoring systems: the Society of Thoracic Surgeons (STS) Predicted Risk of Mortality or Major Morbidity (STS-PROMM)^{26,27} and the EuroSCORE II.^{28,29} The EuroSCORE II includes an assessment of poor mobility, defined as “severe impairment of mobility secondary to musculoskeletal or neurological dysfunction” that contributes to mortality. The most recent version of the STS score also incorporates gait speed as a surrogate for frailty. However, neither instrument adjusts for functional capacity or dementia, thus limiting their utility in patients ≥ 75 years of age.

As a result of increased cardiac and noncardiac morbidity, as well as age-associated declines in cardiac reserve and homeostasis, older patients are at increased risk for major perioperative complications, including stroke, cognitive dysfunction and delirium, renal failure, respiratory failure, and gastrointestinal disorders. The guideline highlights the marked increase in operative mortality that occurs in patients aged 75 to 79 years and those >80 years of age undergoing CABG.^{30,31} In studies published from 2000 to 2007, operative mortality was up to 2-fold higher in octogenarians, and the rate of discharge to home was half that of younger patients.^{32–34} Average intensive care unit and total hospital length of stay are also longer in older patients.

Recommendations to Close Knowledge Gaps

[Note: Recommendations marked with an asterisk (*) also apply to the section on ACS.]

- Research is needed to determine the impact of IHD on symptoms, activities of daily living, health status, and maintenance of independence in older adults. Improved recognition and management of symptoms has the potential to enhance function and quality of life for older adults with IHD.*
- Studies are needed to better define the role of pharmacological stress imaging in the diagnosis and management of stable IHD in older adults. Although imaging increases the sensitivity of ischemic assessment, overreliance on imaging may potentially lead to management

that is dissociated from symptoms and patient preferences. Conversely, underutilization of imaging may lead to underdiagnosis and undertreatment, with the potential for detrimental effects on patient-centered outcomes.

- Studies are needed to assess the utility of alternative methods to traditional stress testing to assess symptoms and functional status in older patients, such as submaximal exercise tests, walk tests, gait speed, gait variability, cardiopulmonary indices, strength indices (eg, hand grip), and mental stress indices, as metrics to guide IHD management.
- The comparative effectiveness of medical therapy versus early invasive management (including PCI and CABG), particularly with respect to quality of life, functional capacity, and medication use, warrants further investigation in older adults.
- Studies are needed to evaluate the potential role of physical conditioning before major procedures as a means for reducing periprocedural risk and improving postprocedural outcomes.
- Studies are needed to refine the utility of cardiac rehabilitation programs to optimize functional capacity, reduce disability and fall risk, preserve independence, decrease hospital and long-term care admissions, and lower healthcare costs in older patients with IHD.*
- Studies are also needed to improve referral and adherence to cardiac rehabilitation among older adults, including patients with multimorbidity, noncardiovascular functional limitations, and frailty.*
- Studies are needed to assess the effectiveness and comparative effectiveness of various antithrombotic regimens in older patients with or without relevant comorbidities (eg, concomitant atrial fibrillation [AF], advanced renal insufficiency, or high risk for falls or bleeding).*
- Studies are needed to evaluate the importance of the patient’s attitudes and psychological reserve (eg, drive to recover/will to live) as factors that impact the likelihood of a favorable outcome after cardiac surgery.³⁵
- Studies are needed concerning how best to assess and incorporate advance care planning into the decision-making

process before a major intervention is undertaken and whether early consideration of goals of care influences choice of therapy.*

- Additional studies are needed to develop methods for estimating procedural risks and potential benefits over various time horizons that can be used to facilitate shared decision making (eg, what are the risks and benefits of medical therapy versus PCI versus CABG for treatment of chronic IHD in an 80-year-old patient with specific comorbid conditions over periods of 1, 2, and 5 years?).*
- Collaborative studies with neurologists, radiologists, geriatricians, and other disciplines are needed to develop novel imaging techniques, neurocognitive tests, biomarkers, and genetic markers for mild cognitive impairment and dementia and to determine domains of cognitive dysfunction most closely associated with procedural risks and postprocedural outcomes.*
- Studies are needed to identify patients at high risk for postoperative agitation and delirium and to develop strategies for preventing or minimizing and treating these conditions.

Heart Rhythm Disorders

AF and Atrial Flutter

Current Recommendations

The “2014 AHA/ACC/HRS Guideline for the Management of Patients With Atrial Fibrillation” provides a brief subsection (7.2) on AF in the elderly.³⁶ The authors note that ≈35% of patients with AF are >80 years of age. AF may occur in elderly patients without underlying heart disease because of “changes in cardiac structure and function that accompany aging, such as increased myocardial stiffness.” The elderly are a heterogeneous group with potential for multiple comorbidities, and a Table listing the most common coexisting conditions in Medicare beneficiaries with AF is provided.^{36,37} Symptoms are frequently atypical among older patients, and

Table. Ten Most Common Chronic Comorbid Conditions Among Medicare Beneficiaries With Atrial Fibrillation³⁶

Beneficiaries ≥65 y of Age (N=2 426 865) (Mean Number of Conditions=5.8; Median=6)			Beneficiaries <65 y of Age (N=105 878) (Mean Number of Conditions=5.8; Median=6)		
	N	%		N	%
Hypertension	2 015 235	83.0	Hypertension	85 908	81.1
Ischemic heart disease	1 549 125	63.8	Ischemic heart disease	68 289	64.5
Hyperlipidemia	1 507 395	62.1	Hyperlipidemia	64 153	60.6
HF	1 247 748	51.4	HF	62 764	59.3
Anemia	1 027 135	42.3	Diabetes mellitus	56 246	53.1
Arthritis	965 472	39.8	Anemia	48 252	45.6
Diabetes mellitus	885 443	36.5	CKD	42 637	40.3
CKD	784 631	32.3	Arthritis	34 949	33.0
COPD	561 826	23.2	Depression	34 900	33.0
Cataracts	546 421	22.5	COPD	33 218	31.4

AF indicates atrial fibrillation; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; and HF, heart failure. Reproduced from the Centers for Medicare & Medicaid Services.³⁷

palpitations are less common than in younger patients. In discussing medical management, the guideline cautions that older adults may be more prone to heart block, especially with use of amiodarone and digitalis. Increasing age is a potent risk factor for stroke in patients with AF, and this has been highlighted in the CHA₂DS₂-VASc (Congestive heart failure, Hypertension, Age \geq 75, Diabetes mellitus, Stroke or transient ischemic attack, Vascular disease, Age 65-74, Sex category female) risk scoring system, which assigns 1 point for age 65 to 74 years and 2 points for age \geq 75 years. Although most AF trials have enrolled patients without an upper age limit, the mean age of study cohorts is 5 to 10 years younger than the average age of patients with AF in the general population. Therefore, it is unknown whether the findings of these studies can be generalized to patients \geq 75 years of age, and especially those \geq 85 years of age.

In the most recent consensus statement on AF ablation,³⁸ and in the 2014 guideline,³⁶ it is acknowledged that older patients are not well represented in the ablation literature. Data on long-term outcomes after ablation in the older population are lacking. Atrioventricular node ablation to create complete heart block with pacemaker implantation to maintain a regular rhythm in patients for whom pharmacological therapy has failed carries a Class IIa recommendation as an alternative nonpharmacological approach to management of patients with symptomatic AF without specific reference to age.^{36,39,40}

Recommendations to Close Knowledge Gaps

- Studies are needed to better understand mechanisms underlying interactions between common diseases (coronary artery disease, hypertension, diabetes mellitus, heart failure (HF), obstructive sleep apnea, obesity) and age-mediated changes in atrial structure, function, biochemistry, and biophysics that increase the propensity to develop AF with increasing age.
- Noninvasive tools are needed to study and quantify aging-related structural and electrophysiological changes and remodeling that promote AF.
- Novel biomarkers or monitoring devices aimed at primary prevention or early detection of AF in the older population should be sought, because many strokes occur in patients with subclinical AF.^{41,42}
- Mechanisms that explain racial variations in AF prevalence with advancing age (eg, less common among older blacks despite higher prevalence of risk factors) should be sought, because these may provide insights into pathophysiology.
- Studies are needed to refine predictive models for both thromboembolic and bleeding complications in older adult patients with AF. In addition to clinical characteristics, including the impact of multimorbidity and frailty, structural factors and biological and genetic markers warrant further investigation.
- The value of novel point-of-care calculators (eg, the Stroke Prevention in Atrial Fibrillation Risk Tool⁴³) for estimating benefits and bleeding risks associated with antithrombotic therapy and as an aid to clinical decision making in older adults with AF should be tested.

- Comparative effectiveness studies, large registries, and mandatory postmarketing surveillance databases are needed to define specific clinical situations in which one anticoagulant offers a superior benefit-to-risk profile relative to other available treatments.
- Studies are also needed to determine the consequences of nonadherence with anticoagulation therapy, as well as whether risks of adverse events differ across current and emerging anticoagulant agents.
- Additional studies of nonpharmacological approaches to stroke prevention, such as procedures that occlude or ligate the left atrium, are needed in older populations.
- Studies are needed to define criteria for withholding and withdrawing anticoagulants in older patients (eg, because of terminal illness or excessive risking of bleeding).
- Studies are needed to test the differences between rate and rhythm control strategies on clinical outcomes relevant to older populations, such as quality of life and functional status.
- Risks and benefits of AF ablation should be studied in older populations with respect to short- and long-term outcomes, including quality of life and healthcare costs.
- Studies are needed to determine the appropriate use of anticoagulation therapy after successful AF ablation.
- Studies are needed to assess the impact of atrioventricular node ablation with pacemaker implantation on quality of life and other relevant outcomes in older patients with AF.

Ventricular Arrhythmias and Prevention of Sudden Cardiac Death

Current Recommendations

The “ACC/AHA/ESC 2006 Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death” include a section devoted to the management of older adults.⁴⁴ The guidelines note that although the incidence of ventricular arrhythmias increases with age, there appears to be a decline in sudden cardiac death after age 80 years because of competing causes of death. In general, medical therapy for ventricular arrhythmias does not differ by age, but dosage adjustment because of alterations in renal and hepatic clearance and changes in volume of distribution must be considered. The guidelines do not discuss catheter ablation, surgical interventions, or revascularization as secondary prevention strategies for ventricular arrhythmias in older adults.

Recommendations to Close Knowledge Gaps

- Improved noninvasive risk stratification tools are needed to identify older adults at increased risk of sudden cardiac death. Screening tools should be applicable to a broad spectrum of older adults, including those with functional and cognitive limitations.
- Studies of prevention of sudden cardiac death should include quality-of-life end points and quality-adjusted life-years added, because these outcomes may be of particular concern to older adults.
- Studies are needed to understand the role of catheter ablation of ventricular arrhythmias in older adults.

- Studies of competing risks should be performed to assess the relative risk of death caused by arrhythmias compared with death from other causes.
- Point-of-care resources are needed to assist healthcare providers in appropriately dosing antiarrhythmic drugs in older adults, including consideration of drug interactions and age-related alterations in pharmacokinetics.

Device-Based Therapy for Cardiac Rhythm Abnormalities

Current Recommendations

Both the “ACC/AHA/ESC 2006 Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death” and “ACC/AHA/HRS 2008 Guidelines for Device-based Therapy of Cardiac Rhythm Abnormalities” have sections devoted to older adults.^{44,45} The 2006 guidelines note that “comorbidities, life expectancy, and quality-of-life issues must be addressed forthrightly with patients and their families.”⁴⁴ The guidelines specifically state that a device should not be placed in a person with a life expectancy <1 year.

Class I indications for pacemaker implantation and for cardiac resynchronization therapy are similar in older and younger patients.^{46,47} The 2012 guideline update supports remote monitoring after the initial 2-week period.⁴⁶ This is of particular importance to older adults, some of whom may have physical limitations that make frequent in-person visits more challenging. However, patients with cognitive impairment may have difficulty performing home-based transmissions. Remote monitoring may also allow for earlier detection of clinical deterioration, thereby leading to reduced readmission rates.

Although the guidelines for implantable cardioverter-defibrillators (ICDs) do not distinguish indications based on age, it is acknowledged that “few clinical trials of device-based therapy have enrolled enough older patients to reliably estimate the benefits of device-based therapy in this group.”⁴⁴ The durability of ICD benefit is shorter and the risk of procedural complications is higher in patients >80 years of age than in younger patients.⁴⁸ Thus, the guideline states that older patients with limited life expectancy may not be suitable candidates for an ICD. Conversely, it is noted that many older patients who die suddenly are fully functional during the month before death.⁴⁹

There is a specific section of the guidelines for device-based therapy that addresses end-of-life planning in patients with cardiac devices, stating that such devices should not be placed in those with life expectancy <1 year.⁵⁰ “These decisions require not only evidence of clinical benefit demonstrated in randomized clinical trials but also estimates of life expectancy, consideration of comorbidities and procedural risk, and patient preferences. Although these factors are important when device implantation is considered in any age group, they assume greater weight in clinical decision making among the elderly.”⁴⁵

The guidelines also have a section on device deactivation. Clinicians who implant devices are encouraged to discuss

end-of-life issues before implantation. If a decision is made to deactivate the device, the conversation should be documented in the record, a do-not-resuscitate order should be placed, and a psychiatry or ethics consultation should be obtained if appropriate.⁵¹ The guidelines opine that “age itself should not be the predominant consideration in the use of device-based therapy among the elderly.”

Recommendations to Close Knowledge Gaps

- More research is needed on mechanisms of degeneration of the cardiac conduction system with increasing age. The potential for conduction cell regeneration (eg, stem cell therapy to treat sinus node dysfunction) in older adults should be explored.
- Better methods are needed for identification of older adults with unexplained syncope who have bradyarrhythmias as the underlying cause (eg, arrhythmia detection patches or implantable loop recorders).
- Studies are needed to determine the impact of cardiac resynchronization therapy, with or without defibrillation, on clinical outcomes, including quality of life and functional status, in older adults.
- Studies to improve management of implanted cardiac devices at the end of life with regard to device disablement and cost-benefit issues are needed.
- Data are needed on outcomes of ICD implantation for primary and secondary prevention of sudden cardiac death in a broad spectrum of older adults, including procedural complications, quality-adjusted life-years gained, and healthcare costs.
- Individualized ICD consent forms need to be developed that estimate the anticipated life extension associated with implantation while accounting for prevalent comorbidities.
- Studies are needed on decision making at the time of generator replacement for battery end of life. Cohort studies to evaluate outcomes of older adults in this setting could provide important insights into the continued need for such devices.

Valvular Heart Disease: Aortic Stenosis

Current Recommendations

The “2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease” section on aortic stenosis (AS) is largely based on data from studies in older adults; therefore, the discussion and recommendations in this section are generally applicable to older adults.⁵² The guideline notes that compared with younger patients, symptoms among older patients are both less sensitive and less specific for AS. Similarly, classic physical findings of AS, such as delayed carotid upstroke, are less common in older adults, in part because of age-related changes in the vasculature.⁵³ Disease progression may also vary in relation to age and sex and tends to be more rapid in older patients.^{54,55}

The guideline emphasizes that age is not a contraindication to aortic valve replacement (AVR),⁵² with several series showing excellent outcomes in very elderly patients undergoing surgical or transcatheter AVR (TAVR).^{56–59} The guideline recommends

determining the operative risk for each individual using an online calculator such as that of the STS (www.sts.org).⁶⁰ It is noted that concomitant diseases (eg, permanent neurological defects or cancer) and severe debilitation have a major impact on outcomes and may make AVR inappropriate. In this regard, the guideline provides a Class III recommendation for TAVR in patients in whom existing comorbidities would preclude the expected benefit from correction of AS (Level of Evidence B). The guideline also states that AVR is not indicated in patients with a life expectancy <1 year or with a likelihood of 2-year survival with benefit <25%. In the PARTNER studies (Placement of Aortic Transcatheter Valves), patients with an STS score ≥ 15 , frailty, porcelain aorta, or prior chest radiation were less likely to benefit from TAVR than those without these features.^{58,61}

The guideline acknowledges the important role of patient preferences in the decision-making process and points out that a multidisciplinary heart valve team may be particularly beneficial in evaluating older patients for possible AVR. In addition, it is noted that certain anatomic factors more common in older adults, such as a narrow left ventricular outflow tract or heavily calcified aortic annulus, may render surgery more challenging in this population.

Recommendations to Close Knowledge Gaps

- Basic and translational studies examining the mechanisms of inflammation and calcification of the aortic valve that lead to the development and progression of AS are essential.
- Interactions between age, sex, race/ethnicity, and comorbidities (eg, hypertension, diabetes mellitus, coronary artery disease, and obesity) with the clinical course and prognosis of older adults with AS should be explored.
- Risk calculators should be developed that include cognitive function, frailty, and functional limitations in the assessment of perioperative morbidity and mortality, as well as long-term outcomes, including functional status and quality of life.
- The potential role of medical therapies in slowing the rate of disease progression and reducing symptoms remains to be established; in addition, the risk versus benefit of any such medications in relation to advanced age, frailty, and comorbidity requires elucidation.
- The role of percutaneous balloon aortic valvuloplasty in selected older adults with severe AS in the era of TAVR remains uncertain and warrants further study.
- Novel techniques are needed to reduce periprocedural complications (eg, stroke, paravalvular aortic regurgitation, heart block, AF, and cognitive impairment/delirium) and to expedite recovery with return to independent living.
- Further studies are needed to determine the role of TAVR in intermediate-risk older adults, in those with predominant aortic regurgitation, and in those with bioprosthetic valve failure.
- Improved methodologies and criteria are needed to refine patient selection to identify patients most likely to benefit from surgical AVR, TAVR, or conservative

management (eg, expected survival <1 year even with successful intervention).

- Further studies are needed to define the pathogenesis and mechanisms of paradoxically low-flow AS, which disproportionately afflicts older adults, as well as the outcomes of such patients with interventional approaches.
- Additional studies are needed to evaluate the impact of pulmonary hypertension, which is common in older patients, on clinical and functional outcomes after AVR.

Heart Failure

Current Recommendations

HF With Reduced Ejection Fraction

The “2013 ACCF/AHA Guideline for the Management of Heart Failure” focuses mainly on the evaluation and management of patients with HF and reduced ejection fraction (HFrEF).⁴⁷ The guideline emphasizes the strong and consistent association of advancing age with the prevalence and incidence of HF, noting that HF is predominantly a disease of older adults and that with the aging of the population, the number of Americans with HF is expected to increase significantly.⁶² The guideline also notes that in older adults, HF is inadequately recognized and treated, often because symptoms are incorrectly attributed to normal aging or other conditions.

Throughout the guideline, special issues pertinent to older adults are highlighted, including the following: the observation that 3% to 4% of blacks carry an allele of the serum protein transthyretin (TTR V122I) that appears to increase risk for cardiac amyloid deposition and HF after 65 years of age; the risk of hyperkalemia with standard pharmacological therapy for HF and the underestimation of renal dysfunction in older adults based on serum creatinine; the association of advancing age with increases in natriuretic peptides, thereby limiting their diagnostic utility and their usefulness in guiding therapy in older adults; uncertainty about the value of revascularization in patients with HF and coronary artery disease but without angina; the increased risk of digoxin toxicity in older adults because of impaired renal function and lower lean body mass; and the stronger association of AF to HF with advancing age. The guideline acknowledges that older adults with HF typically have multimorbidity (75% of HF patients >65 years of age have multiple chronic conditions) and that there is therefore a need to consider comorbid conditions, life expectancy, and personal preferences in the application of medical and device therapies. On the basis of data in younger patients, the guideline suggests that such therapies be used in older patients without an age limit but that treatment be individualized based on each patient’s unique circumstances and goals of care.

There is growing interest in mechanical circulatory support (MCS) as destination therapy for older adults with advanced HFrEF, especially patients more than 70 to 75 years old who are not considered candidates for heart transplantation in most centers. The HF guideline and AHA statement on the use of MCS⁶³ indicate that the decision to use MCS as destination therapy requires a careful evaluation by an expert multidisciplinary team. Advanced age is a risk factor for adverse outcomes, and age ≥ 80 years is considered a relative contraindication to

destination therapy- MCS. Optimal patient selection for MCS is an area of active investigation. Notably, Centers for Medicare & Medicaid Services guidelines for MCS require inclusion of a palliative care specialist on the multidisciplinary team.

Comprehensive discharge planning and postdischarge support with special attention to care transitions should be deployed to achieve guideline-directed medical therapy and prevent hospitalizations, which may in turn improve quality of life and survival without increasing costs. Recognizing that HF is a progressive and incurable disorder, the guideline endorses palliative care as an ongoing component of management, especially for patients hospitalized with recurrent decompensation. Palliative care should include early, regular discussions of prognosis with patients and families; the formulation and implementation of advance directives; ensuring appropriate transitional care across venues (home, emergency department, hospital, skilled nursing facility, hospice); discussions regarding devices and the option of defibrillator deactivation; and optimal relief of symptoms (Class I, Level of Evidence B).^{64,65}

HF With Preserved Ejection Fraction

In contrast to the sections devoted to HFrEF, the section of the 2013 HF guideline devoted to HF with preserved ejection fraction (HFpEF) is brief.⁴⁷ Although the guideline acknowledges that HFpEF accounts for up to 50% of HF in the community and that it is predominantly a disorder of older women with hypertension, often in combination with other comorbidities (eg, obesity, coronary artery disease, diabetes mellitus, AF),⁶⁶ the guideline does not provide recommendations for management of HFpEF because of the inadequacy of the existing evidence base.

The guideline defines diagnostic criteria for HFpEF as signs and symptoms of HF, a normal or near-normal left ventricular ejection fraction, and no other obvious explanation for the patient's symptoms. This simplified, phenomenological approach, without mandate for documentation of diastolic dysfunction or elevated natriuretic peptide levels, is supported by recent studies.

The guideline notes that there are currently no proven effective therapies for HFpEF. All completed clinical trials in HFpEF have been neutral for their primary outcomes. The guideline emphasizes the need for additional research to better define the pathophysiology and treatment of this disorder.

As a consequence of the limited evidence base, treatment recommendations are sparse, largely empiric, and focus on a few general principles: control of hypertension, judicious use of diuretic agents for pulmonary congestion and peripheral edema, control of AF, and treatment of myocardial ischemia in selected patients.

Recommendations to Close Knowledge Gaps

- Pooled data from high-quality clinical trials and large prospective registries should be scrutinized to inform clinicians about the impact of specific drug and device therapies, as well as exercise training and other lifestyle interventions, on relevant outcomes in older adults with HFrEF.⁶⁷
- Data are needed in older patients with left ventricular ejection fractions of 40% to 55% to determine whether

pharmacological therapies improve mortality, hospitalizations, quality of life, or functional capacity in this poorly studied population.

- Studies are needed to determine the value of MCS as destination therapy in older patients with HFrEF, including complication rates, and the impact on quality of life, quality-adjusted life-years, caregiver burden, and healthcare use and costs, as well as whether age-related disorders in cognitive function (including mild cognitive impairment) and frailty are potentially reversible with MCS.
- Studies are needed to better characterize the bidirectional association between HF and cognitive impairment in older adults, evaluate cognitive outcomes in older HF patients, and develop and test interventions that may slow progression of cognitive decline.
- Similarly, studies are needed to further evaluate the impact of depressive symptoms on clinical outcomes and response to therapy in older patients with HF, better understand the intersections between depression and cognitive dysfunction in this population, and develop interventions for these overlapping syndromes.
- Studies are needed to better understand the processes of symptom recognition and the decision to seek treatment in older adults with HF.
- Strategies are needed to ensure optimal care transitions across venues (hospital, skilled nursing facility, emergency department, home) among older HF patients.⁶⁸
- Early and more systematic introduction of palliative care services for older adults with HF, including consideration for hospice care if appropriate, by use of a process of shared decision making is needed to better align patient and family preferences with therapeutic choices for advanced HF care.
- Research is needed on behavioral approaches to managing both acute and chronic HF in patients with either HFrEF or HFpEF. Studies should evaluate dietary and exercise interventions, alone and in combination, and determine their impact on quality of life, functional capacity, body composition, preservation of independence, and clinical events.
- Studies are needed to evaluate specific dietary patterns (eg, sodium and potassium intake, fluid intake), as well as the role of dietary supplements (eg, coenzyme Q10, vitamin D) in older patients with HFrEF or HFpEF and whether optimal intake of these and other nutrients varies as a function of age, renal function, and hepatic function.
- Better understanding of the mechanisms culminating in HFpEF is needed, with the recognition that there is substantial heterogeneity of HFpEF in the older population, that mechanisms of HFpEF likely vary across individuals, and that there is a marked sexual dimorphism.
- More data are needed on peripheral abnormalities, such as arterial and skeletal muscle dysfunction, which appear to be major contributors to exercise intolerance in HFpEF. Therapies that target these abnormalities warrant further investigation, particularly because skeletal muscle has robust capacity for rapid regeneration and remodeling.
- Studies that consider HFpEF as a marker for loss of global reserve capacity in multiple organ systems and as a systemic disorder, rather than merely as an isolated

cardiac or vascular abnormality (eg, myocardial stiffness), could lead to significant advances in prevention and management.

Peripheral Arterial Disease

Current Recommendations

The “ACC/AHA 2005 Practice Guidelines for the Management of Patients With Peripheral Arterial Disease” and the “2011 ACCF/AHA Focused Update” address the diagnosis and treatment of peripheral arterial disease (PAD) in 4 extracardiac vascular beds (abdominal aorta, renal and mesenteric arteries, and the lower limb arteries).^{69,70} The guidelines highlight the strong and consistent association of advancing age with the prevalence and incidence of PAD. Age >70 years is noted to be an independent risk factor for the development of PAD involving the lower extremities, irrespective of other risk factors, with prevalence rates of >20% in both men and women in this age group. Given the strong effect of age on PAD prevalence, the guidelines endorse as a Class I (Level of Evidence C) recommendation that providers inquire in adults ≥50 years of age about a family history of abdominal aortic aneurysm among first-degree relatives to identify high-risk individuals who may require additional evaluation. For older adults who may have noncompressible arteries because of calcification, caution is advised about limitations of the ankle brachial index for diagnosing PAD and the potential for false-negative results. Recognizing that many older adults are not able to exercise on a treadmill because of comorbid conditions, the guidelines recommend the use of hall walks for evaluation of functional capacity and to assess response to therapy and prognosis. There is also recognition that consideration of life expectancy is essential for development of patient-centered treatment recommendations for the management of PAD, a point that is especially relevant to older adults who may have competing causes for future morbidity and mortality.

Recommendations to Close Knowledge Gaps

- Comparative effectiveness studies are needed in patients with PAD who are >75 years of age and are treated with medical, surgical, or percutaneous interventions.
 - Studies are needed on the impact of PAD on quality of life and functional outcomes, including absence of disability (eg, performance of activities of daily living), mobility, gait speed, and independence in older adults.
 - Studies are needed to assess the utility of pharmacological therapies (antiplatelet agents, lipid-lowering drugs, anticoagulant agents, phosphodiesterase inhibitors, and others) in the context of competing conditions (an average of ≥3 comorbidities)⁷¹ in older adults with PAD.
 - To identify new targets for pharmacological therapy, research that delineates the biological mechanisms underlying the propensity of older adults to develop PAD is warranted.
 - The intersection of PAD with age-related declines in skeletal muscle mass and function (sarcopenia)⁷¹ that contribute to the development of functional impairments (eg, gait speed) and subsequent disability warrants further investigation, with emphasis on interventions that could optimize functional outcomes and quality of life.
- Research is needed on the use of exercise interventions to optimize function and decrease disease progression, especially the type, amount, and intensity of activity required to achieve benefit in the oldest old (ie, patients ≥85 years of age).
 - Studies are needed to determine the predictive value of impaired functional capacity attributable to PAD and the impact of interventional therapies for the prevention of critical limb ischemia and limb loss.

Cerebrovascular Disease and Stroke

Current Recommendations

Cerebrovascular disease and stroke comprise several discrete and heterogeneous conditions, mostly affecting elderly patients. Since 2010, there have been at least 11 ASA/AHA guidelines and scientific statements related to cerebrovascular disease and stroke.^{72–82} Common themes are that older adults tend to have more complex anatomy and greater vessel tortuosity and that older adults are at increased risk for adverse outcomes from stroke (higher likelihood of hemorrhagic transformation, reduced neurological recovery, and increased mortality), as well as from pharmacological, percutaneous, and surgical interventions. It is also acknowledged that older patients and women have been underrepresented in clinical trials and that additional research is needed to better define optimal prevention and treatment for cerebrovascular disease and stroke in these populations.

The 2014 scientific statement on “Palliative and End-of-Life Care in Stroke” from the AHA/ASA promotes a focus on “patient and family-centered care that optimizes quality of life by anticipating, preventing, and treating suffering,” while also recommending a balanced and collaborative approach to end-of-life decision making. These issues cut across all types of stroke and are especially important in elderly stroke patients.⁸⁰ Recommendations and comments specific to elderly patients include the following:

- For chronic poststroke pain, pharmacological treatment with amitriptyline or lamotrigine is reasonable, although in older adults, given the side effects associated with amitriptyline, nortriptyline may be a reasonable substitute (Class IIa; Level of Evidence B).
- In vulnerable populations (older adults and those with impaired communication), there should be enhanced strategies for detection and monitoring of symptoms, including pain, “including verbal descriptor scales, caregiver report, and knowledge of pain behaviors.”⁷⁵

Ischemic stroke is by far the most common type of stroke in the United States and is covered in 8 of the 11 recent guidelines, although none have sections specifically devoted to the elderly.^{73,74,77–82} There are a number of recommendations and comments related to the care of elderly patients with acute ischemic stroke:

- The effectiveness of intravenous treatment with recombinant tissue plasminogen activator is not well established (Class IIb; Level of Evidence C) and requires further study for patients who can be treated in the time period of 3 to 4.5 hours after stroke but have ≥1 of the following

exclusion criteria: (1) patients >80 years old, (2) those taking oral anticoagulants, even with international normalized ratio ≤ 1.7 , (3) those with a baseline National Institutes of Health Stroke Scale score >25, or (4) those with a history of both stroke and diabetes mellitus.⁷⁸

- Decompressive surgery for malignant edema of the cerebral hemisphere is effective and potentially lifesaving (Class I; Level of Evidence B). Advanced patient age and patient/family valuations of achievable outcome states may affect decisions regarding surgery.⁷⁸
- The efficacy of decompressive craniectomy in patients >60 years of age and the optimal timing of surgery are uncertain (Class IIb; Level of Evidence C).⁸²
- The value of surgery for elderly patients with massive cerebellar lesions (ischemic or hemorrhagic) and severe comorbidities has never been examined formally; in these cases, the decision to proceed with surgery needs to be individualized with consideration of the overall prognosis for recovery and the patient's wishes.⁸⁰

Intravenous tissue plasminogen activator remains somewhat controversial in ischemic stroke patients >80 years old, although the Third International Stroke Trial (IST-3) suggested that the benefit of tissue plasminogen activator was at least as great in patients ≥ 80 years of age as in younger patients.⁸³ In 2014, the DESTINY II study (Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery II) reported results of a randomized trial of decompressive hemicraniectomy versus conservative management in patients ≥ 61 years of age (median age 70 years) with large middle cerebral artery ischemic stroke. Although there were significantly more patients "without severe disability" (modified Rankin Scale score ≤ 4) in the hemicraniectomy group, the majority of these patients were still dependent for most activities of daily living.⁸⁴

Multiple guidelines and statements raise age-specific issues for primary stroke prevention, including the following:

- Aggressive management of blood pressure coupled with antithrombotic prophylaxis in elderly patients with AF can be useful (Class IIa; Level of Evidence B).⁷⁴
- Across the spectrum of age groups, including adults >80 years of age, the benefit of hypertension treatment in preventing stroke is clear.⁷⁴
- The benefits versus risks of the combined use of antiplatelet agents in addition to warfarin in elderly AF patients are inadequately defined.⁷⁴
- Given the increased prevalence of AF with age and the higher risk of stroke in elderly women with AF, active screening (in particular of women >75 years of age) in primary care settings using pulse taking followed by an electrocardiogram as appropriate is recommended (Class I; Level of Evidence B).⁷⁹
- Carotid duplex ultrasound screening is reasonable before elective CABG surgery in patients >65 years of age and in those with left main coronary stenosis, PAD, a history of cigarette smoking, a history of stroke or transient ischemic attack, or carotid bruit (Class IIa; Level of Evidence: C).⁷³

Secondary ischemic stroke prevention recommendations focused on the elderly include the following:

- Apixaban 5 mg twice daily is a relatively safe and efficacious alternative to warfarin or aspirin in patients with nonvalvular AF deemed appropriate for vitamin K antagonist therapy who have at least 1 additional risk factor and no more than 1 of the following characteristics: age ≥ 80 years, weight ≤ 60 kg, or serum creatinine ≥ 1.5 mg/dL (Class I; Level of Evidence B).⁷⁷
- Although its safety and efficacy have not been established, apixaban 2.5 mg twice daily may be considered as an alternative to warfarin or aspirin in patients with nonvalvular AF deemed unsuitable for vitamin K antagonist therapy who have at least 1 additional risk factor and ≥ 2 of the following criteria: age ≥ 80 years, weight ≤ 60 kg, or serum creatinine ≥ 1.5 mg/dL (Class IIb; Level of Evidence C).⁷⁷
- The decision to restart antithrombotic therapy after intracerebral hemorrhage (ICH) related to antithrombotic therapy depends on the risk of subsequent arterial or venous thromboembolism, the risk of recurrent ICH, and the overall status of the patient and must therefore be individualized. For patients with a comparatively lower risk of cerebral infarction (eg, AF without prior ischemic stroke) and a higher risk of recurrent ICH (eg, elderly patients with lobar ICH or presumed amyloid angiopathy) or with very poor overall neurological function, an antiplatelet agent may be considered for prevention of ischemic stroke (Class IIb; Level of Evidence B).⁸¹
- It is reasonable to consider patient age in choosing between carotid artery stenting and carotid endarterectomy. For patients >70 years of age, carotid endarterectomy may be associated with improved outcome compared with carotid artery stenting, particularly when arterial anatomy is unfavorable for endovascular intervention. For younger patients, carotid artery stenting is equivalent to carotid endarterectomy in terms of risk for periprocedural complications (ie, stroke, myocardial infarction, or death) and long-term risk for ipsilateral stroke (Class IIa; Level of Evidence B).⁸¹

ICH is the most lethal form of stroke, especially in the elderly. One recommendation from the 2010 "Guidelines for the Management of Spontaneous Intracerebral Hemorrhage"⁷² makes reference to older age:

- In situations where stratifying a patient's risk of recurrent ICH may affect other management decisions, it is reasonable to consider the following risk factors for recurrence: lobar location of the initial ICH, older age, ongoing anticoagulation, presence of the apolipoprotein $\epsilon 2$ or $\epsilon 4$ alleles, and greater number of microbleeds on magnetic resonance imaging (Class IIa; Level of Evidence: B).

Recently, the 2013 report of the STICH II trial (Surgical Trial in Lobar Intracerebral Hemorrhage; $\approx 40\%$ ≥ 70 years of age) suggested the possible benefit of early surgical intervention, specifically for superficial ICHs. The benefit of early surgery in superficial ICHs may be accentuated in patients with a poor prognosis, with older age being a prominent risk factor for poor prognosis.⁸⁵

Prognostic models for ICH outcomes may be overly pessimistic because of biases introduced by the inclusion of patients managed with comfort measures only or withdrawal of life support. Thus, there is a recommendation for aggressive full

care early after ICH onset and postponement of new do-not-resuscitate orders until at least the second full day of hospitalization to better allow time for appropriate family counseling and decision making (Class IIa; Level of Evidence: B).⁷² However, this recommendation may not be as relevant for older patients, especially those with severe hemorrhages, who more commonly have significant medical comorbidities and preestablished end-of-life care plans.⁷²

Subarachnoid hemorrhage is most commonly caused by rupture of an intracranial aneurysm. The 2012 “Guidelines for the Management of Aneurysmal Subarachnoid Hemorrhage” include 1 recommendation and 1 comment related to the elderly⁷⁶:

- Microsurgical clipping may receive increased consideration in patients presenting with large (>50 mL) intraparenchymal hematomas and middle cerebral artery aneurysms. Endovascular coiling may receive increased consideration in the elderly (>70 years of age), in those presenting with poor-grade (World Federation of Neurological Surgeons classification IV/V) subarachnoid hemorrhage, and in those with aneurysms of the basilar apex (Class IIb; Level of Evidence C).
- In older patients with degenerative vascular diseases, computed tomographic angiography can replace catheter cerebral angiography in most cases if the image quality is excellent and analysis is performed carefully.

A comment from the 2014 “Palliative and End-of-Life Care in Stroke” statement cautions that “although elderly, comatose patients with poor-grade SAH [subarachnoid hemorrhage] have a high likelihood of a poor outcome, it still may be reasonable to attempt a limited trial of aggressive treatment for some patients given the potential for considerable recovery.”⁸⁰

Vascular cognitive impairment is primarily a condition of the elderly and is caused by clinical strokes, silent strokes, and white matter lesions. It is the second most common cause of dementia and overlaps with Alzheimer disease in a substantial proportion of patients. The entire statement “Vascular Contributions to Cognitive Impairment and Dementia” focuses on the role of cerebrovascular pathology and the development of late-life dementia, and thus, the elderly.⁷⁵ Recommendations specifically pertaining to the elderly include the following:

- There is reasonable evidence that in the middle-aged and young-elderly, lowering blood pressure can be useful for the prevention of late-life dementia (Class IIa; Level of Evidence B).
- The usefulness of lowering blood pressure in people >80 years of age for the prevention of dementia is not well established (Class IIb; Level of Evidence B).

Recommendations to Close Knowledge Gaps

- Comparative effectiveness studies are needed to assess short- and long-term outcomes in elderly patients with all stroke types and to define which patients are most likely to benefit from specific interventions.

- Additional research is needed to identify the best approaches to help families understand the range of possible functional outcomes in elderly patients with severe stroke and to use that information to make individualized decisions about continued aggressive care based on their understanding of the patient’s wishes.
- Studies are needed to establish optimal blood pressure targets and intensity of statin therapy for primary and secondary stroke prevention in older adults.
- The role of thrombolysis for acute ischemic stroke in the elderly requires further clarity.
- Further research is needed to better understand which elderly patients benefit from carotid interventions, why elderly patients appear to fare better with carotid endarterectomy, and whether management of their care should differ from that for younger patients.⁷³
- Additional large-scale magnetic resonance imaging studies of cerebral microhemorrhages as predictors of cerebral macrohemorrhages may prove to be useful in relation to the safety of administration of antithrombotic agents, especially in the elderly.⁷⁴
- Research is needed to develop and test novel less invasive approaches to ICH decompression for older patients.
- Additional research should better define the risk-benefit ratio of various antithrombotic therapies for the elderly who have competing risks of ischemic and hemorrhagic stroke.
- Studies are needed to better understand the relationship between location, severity, and extent of vascular brain injury and the resultant cognitive syndromes, while simultaneously accounting for coexisting age-related pathologies and cognitive reserve. These programs should include a search for genetic and other novel factors with an overarching goal to identify new strategies for prevention or treatment of vascular cognitive impairment.⁷⁵

Perioperative Management for Noncardiac Surgery

Current Recommendations

Older adults account for the majority of major surgical procedures performed in the United States and Europe, and it is estimated that the rate of surgery is up to 4-fold higher in older adults than in younger people.⁸⁶ In addition, because the prevalence of CVD increases progressively with age, the probability that an adult undergoing surgery has CVD (asymptomatic or symptomatic) also rises rapidly with age. Numerous studies have shown that advanced age (eg, ≥80 years) is an independent predictor of perioperative complications and death after both cardiac and noncardiac surgery.^{87,88} Furthermore, older adults undergoing major surgery are at heightened risk for a host of noncardiac complications, including infections, pulmonary disorders (eg, prolonged requirement for mechanical ventilation), renal insufficiency, postoperative cognitive impairment and delirium, gastrointestinal problems (eg, anorexia, ileus), deep venous thrombosis and pulmonary embolism, dermatologic problems (eg, pressure ulcers), and deconditioning.⁸⁹ Taken together, these complications result in increased length of stay, increased likelihood of discharge to a transitional care

or chronic care facility, increased risk for disability and dependency, reduced quality of life, and diminished likelihood of full recovery to preoperative levels of physical and mental function.

The “2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery” acknowledges that older adults are at increased risk for perioperative cardiac complications and death.⁸⁶ The guideline recommends the use of validated prediction tools for assessing risk of perioperative major adverse cardiac events.^{90,91} In addition to age and functional status, sex is considered in the American College of Surgeons NSQIP (National Surgical Quality Improvement Program) Surgical Risk Calculator.⁹⁰ However, although the guideline recognizes the impact of advanced age and functional limitations on surgical risk, it does not consider other geriatric issues, such as cognitive function, frailty, and multimorbidity, in risk assessment, and it does not include recommendations specific to the geriatric population.⁸⁶

Recommendations to Close Knowledge Gaps

- Studies are needed to develop methods to incorporate global risk (including, for example, multimorbidity, cognitive function, and frailty) and long-term outcomes relevant to older adults, such as maintenance of independence, preservation of physical and mental function, and overall quality of life, into preoperative cardiovascular risk assessment.
- Similarly, tools are needed to more accurately assess global risk in older patients referred for major cardiac and noncardiac surgical procedures, especially those ≥ 80 years of age and those ≥ 90 years of age, because data in these populations are sparse.
- Studies are needed to compare surgical risk calculators with respect to prediction of perioperative and long-term outcomes relevant to older adults.
- Additional studies are needed to better define what preoperative, perioperative, and postoperative tests and interventions are most efficacious in reducing cardiovascular risk in older patients undergoing cardiac and noncardiac surgery.
- Additional research is also needed to better define the significance and optimal management of small postoperative elevations of troponin, especially given the increasing use of high-sensitivity troponin assays.
- Research is needed to develop strategies to define and incorporate patient preferences and goals of care into the decision-making process in older patients before major surgical procedures.
- Interventions are needed to reduce the risk of common complications (eg, delirium, functional decline, disability, renal insufficiency, pneumonia and other infections) and enhance functional outcomes in older patients undergoing major surgery.
- Comparative effectiveness studies are needed to evaluate outcomes with conservative management versus treatment in older patients with nonemergent conditions.

Summary

Despite the high prevalence of CVD in older adults, there is limited evidence to guide clinical decision making in patients

>75 to 80 years of age, and virtually no high-quality evidence in patients >80 years of age with multiple coexisting conditions, major physical or cognitive disabilities, frailty, or residence in long-term care facilities. Moreover, there is little guidance for how to manage CVD and related interventions at the end of life. There is also a pervasive lack of information on the impact of diagnostic and therapeutic interventions on patient-centered outcomes in older adults, including quality of life, functional outcomes (eg, ability to perform routine activities of daily living and instrumental activities of daily living), and maintenance of independence. Often there is an overemphasis on pharmacological and surgical or catheter-based interventions, with much less attention given to nonpharmacological interventions such as diet, lifestyle, and exercise. Care of older adults is also impacted by age-associated alterations in physiology of the cardiovascular system and other organ systems, as well as by mounting chronic comorbidities and disabilities. Although older patients with CVD are at increased risk for adverse outcomes, including death, such that the absolute benefit of effective therapeutic interventions is potentially greater than in younger patients, older patients are also at increased risk for complications arising from both pharmacological agents and diagnostic and therapeutic procedures. Thus, there is a fundamental shift in the balance of risk and benefit in older patients that has been inadequately addressed in clinical trials and that must be considered on an individualized basis. The present scientific statement summarizes vital knowledge and evidence gaps relevant to common cardiovascular disorders with high prevalence in older adults. To overcome these deficiencies, there is a critical need for a multitude of large population-based studies and clinical trials using novel study designs that incorporate patient-centered outcomes relevant to older patients and, most importantly, that include a broad mix of older patients typical of those seen in clinical practice. The results of these studies will enable translation of key findings into future evidence-based guidelines, thereby transforming care and enhancing outcomes for the growing population of older people with CVD in the United States and around the world.

Appendix: List of ACC/AHA/ASA Guidelines Reviewed

- 2013 ACCF/AHA Guideline for the Management of ST-Elevation Myocardial Infarction¹²
- 2014 AHA/ACC Guideline for the Management of Patients With Non-ST-Elevation Acute Coronary Syndromes¹⁶
- 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the Diagnosis and Management of Patients With Stable Ischemic Heart Disease¹⁹
- 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention²⁰
- 2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery²⁵
- 2014 AHA/ACC/HRS Guideline for the Management of Patients With Atrial Fibrillation³⁶
- ACC/AHA/ESC 2006 Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death⁴⁴

- 2012 ACCF/AHA/HRS Focused Update Incorporated Into the ACCF/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities⁴⁶
- 2013 ACCF/AHA Guideline for the Management of Heart Failure⁴⁷
- 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease⁵²
- 2011 ACCF/AHA Focused Update of the Guideline for the Management of Patients With Peripheral Artery Disease⁷⁰
- Guidelines for the Management of Spontaneous Intracerebral Hemorrhage (2010)⁷²
- 2011 ASA/ACCF/AHA/AANN/AANS/ACR/ASNR/CNS/SAIP/SCAI/SIR/SNIS/SVM/SVS Guideline on the Management of Patients With Extracranial Carotid and Vertebral Artery Disease⁷³
- Guidelines for the Primary Prevention of Stroke (2010)⁷⁴
- Guidelines for the Management of Aneurysmal Subarachnoid Hemorrhage (2012)⁷⁶
- Guidelines for the Early Management of Patients With Acute Ischemic Stroke (2013)⁷⁸
- Guidelines for the Prevention of Stroke in Women (2014)⁷⁹
- Guidelines for the Prevention of Stroke in Patients With Stroke and Transient Ischemic Attack (2014)⁸¹
- 2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery⁸⁶

Additional Resources

- Guidelines for the Management of Spontaneous Intracerebral Hemorrhage: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association (2015)⁹²
- Guidelines for the Primary Prevention of Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association (2014)⁹³

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Writing Group Disclosures

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Michael W. Rich	Washington University School of Medicine	NIA*; NHLBI*	None	None	None	None	None	None
Deborah A. Chyun	New York University	None	None	None	None	None	Qatar National Research Fund*	None
Karen P. Alexander	Duke University Medical Center	None	None	None	None	None	None	None
Daniel E. Forman	University of Pittsburgh Medical Center	None	None	None	None	None	None	None
Dalane W. Kitzman	Wake Forest University School of Medicine	NIH†; Novartis†	None	None	None	Gilead, Inc. Stock Ownership†; Relysa Inc.*	GSK*; Relysa*; Regeneron*; AbbVie†; DC Devices*; Abbott Pharmaceuticals*; Actavis*; ICON†	None
Mathew S. Maurer	Columbia College of Physicians and Surgeons	None	None	None	None	None	None	None
James B. McClurken	Doylestown Health Heart Institute	Silver AMI*	None	None	None	None	None	None
Barbara M. Resnick	University of Maryland	None	None	None	None	None	None	None
Win K. Shen	Mayo Clinic	None	None	None	None	None	None	None
Adam H. Skolnick	NYU School of Medicine	None	None	None	None	None	None	None
David L. Tirschwell	Harborview Medical Center	St. Jude Medical†; Bayer*	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Reviewer Disclosures

Reviewer	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
Jeffrey L. Anderson	Intermountain Healthcare	None	None	None	None	None	None	None
Susan Bell	Vanderbilt University	NIH/NICHD (2K12HD043483-11)†	Eisenstein Women's Heart Fund*	None	None	None	None	None
James Blankenship	Geisinger Medical Center	None	Tryton Medical*; Abiomed*; AstraZeneca*; Boston Scientific*; Regado Biosciences*; Volcano*; Abbott Vascular* (Principal Investigator at Geisinger Medical Center for multicenter industry-funded research trials sponsored by these companies)	None	None	None	None	None
Joseph P. Drozda	Mercy Health	None	None	None	None	None	None	My nondependent son is a sales representative for Boston Scientific Corporation†
Andrew E. Epstein	University of Pennsylvania	Biotronik†; Boston Scientific†; Medtronic; Sorin Medical†; St. Jude Medical†	None	None	Yes (1 current case)*	None	Boston Scientific†; Medtronic†; St. Jude Medical†; Population Health Research Institute*	None
Lee A. Fleisher	University of Pennsylvania	None	None	None	None	None	Member, Medical Advisory Board to Technical Expert Panel of Blue Cross/Blue Shield Association*	None
Rebecca Gary	Emory University	None	None	None	None	None	None	None
Sarah Goodlin	Portland VAMC	Medtronic*	None	None	None	None	None	None
Lawrence Izzo	State University of New York at Buffalo; Erie County Medical Center	None	None	None	None	None	None	None
Mariell Jessup	University of Pennsylvania Heart and Vascular Center	None	None	None	None	None	None	None
Glenn N. Levine	Baylor College of Medicine; Michael E. DeBakey Medical Center	None	None	None	None	None	None	None
Patrick O'Gara	Brigham and Women's Hospital, Boston, MA	NHLBI, Cardiothoracic Surgery Network†	None	None	None	None	None	None
Catherine M. Otto	University of Washington School of Medicine	None	None	None	None	None	None	None
Lawrence Rudski	Jewish General Hospital, Montreal, Quebec	None	None	None	None	None	None	None
Nanette Wenger	Emory University School of Medicine	Gilead Sciences†; NHLBI†; Pfizer*	None	None	None	None	Amgen*; AstraZeneca*; Gilead Sciences†	None

This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

References

- Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, Das SR, de Ferranti S, Després J-P, Fullerton HJ, Howard VJ, Huffman MD, Isasi CR, Jiménez MC, Judd SE, Kissela BM, Lichtman JH, Lisabeth LD, Liu S, Mackey RH, Magid DJ, McGuire DK, Mohler ER III, Moy CS, Muntner P, Mussolino ME, Nasir K, Neumar RW, Nichol G, Palaniappan L, Pandey DK, Reeves MJ, Rodriguez CJ, Rosamond W, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Woo D, Yeh RW, Turner MB; on behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2016 update: a report from the American Heart Association. *Circulation*. 2016;133:e38–e360.
- Heron M. Deaths: leading causes for 2010. *Natl Vital Stat Rep*. 2013;62:1–96.
- Moran AE, Forouzanfar MH, Roth GA, Mensah GA, Ezzati M, Murray CJ, Naghavi M. Temporal trends in ischemic heart disease mortality in 21 world regions, 1980 to 2010: the Global Burden of Disease 2010 study. *Circulation*. 2014;129:1483–1492. doi: 10.1161/CIRCULATIONAHA.113.004042.
- Murray CJ, Lopez AD. Alternative projections of mortality and disability by cause 1990–2020: Global Burden of Disease Study. *Lancet*. 1997;349:1498–1504. doi: 10.1016/S0140-6736(96)07492-2.
- Yazdanyar A, Newman AB. The burden of cardiovascular disease in the elderly: morbidity, mortality, and costs. *Clin Geriatr Med*. 2009;25:563–577, vii. doi: 10.1016/j.cger.2009.07.007.
- Herrera AP, Snipes SA, King DW, Torres-Vigil I, Goldberg DS, Weinberg AD. Disparate inclusion of older adults in clinical trials: priorities and opportunities for policy and practice change. *Am J Public Health*. 2010;100(suppl 1):S105–S112. doi: 10.2105/AJPH.2009.162982.
- Heiat A, Gross CP, Krumholz HM. Representation of the elderly, women, and minorities in heart failure clinical trials. *Arch Intern Med*. 2002;162:1682–1688.
- Kitzman DW, Rich MW. Age disparities in heart failure research. *JAMA*. 2010;304:1950–1951. doi: 10.1001/jama.2010.1592.
- Lakatta EG, Levy D. Arterial and cardiac aging: major shareholders in cardiovascular disease enterprises: part I: vascular arteries: a “set up” for vascular disease. *Circulation*. 2003;107:139–146.
- Lakatta EG, Levy D. Arterial and cardiac aging: major shareholders in cardiovascular disease enterprises: part II: the aging heart in health: links to heart disease. *Circulation*. 2003;107:346–354.
- Arnett DK, Goodman RA, Halperin JL, Anderson JL, Parekh AK, Zoghbi WA. AHA/ACC/HHS strategies to enhance application of clinical practice guidelines in patients with cardiovascular disease and comorbid conditions: from the American Heart Association, American College of Cardiology, and US Department of Health and Human Services. *Circulation*. 2014;130:1662–1667. doi: 10.1016/CIR.0000000000000128.
- O’Gara PT, Kushner FG, Ascheim DD, Casey DE, Jr., Chung MK, de Lemos JA, Ettinger SM, Fang JC, Fesmire FM, Franklin BA, Granger CB, Krumholz HM, Linderbaum JA, Morrow DA, Newby LK, Ornato JP, Ou N, Radford MJ, Tamis-Holland JE, Tommaso CL, Tracy CM, Woo YJ, Zhao DX, Anderson JL, Jacobs AK, Halperin JL, Albert NM, Brindis RG, Creager MA, DeMets D, Guyton RA, Hochman JS, Kovacs RJ, Ohman EM, Stevenson WG, Yancy CW. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines [published correction appears in *Circulation*. 2013;128:e481]. *Circulation*. 2013;127:e362–e425. doi: 10.1161/CIR.0b013e3182742cf6.
- Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, Hochman JS, Krumholz HM, Kushner FG, Lamas GA, Mullany CJ, Ornato JP, Pearle DL, Sloan MA, Smith SC Jr. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines for the Management of Patients With Acute Myocardial Infarction) [published corrections appear in *Circulation*. 2005;111:2013–2014, *Circulation*. 2007;115:e411, and *Circulation*. 2010;121:e441]. *Circulation*. 2004;110:e82–e292.
- Antman EM, Hand M, Armstrong PW, Bates ER, Green LA, Halasyamani LK, Hochman JS, Krumholz HM, Lamas GA, Mullany CJ, Pearle DL, Sloan MA, Smith SC Jr, Anbe DT, Kushner FG, Ornato JP, Jacobs AK, Adams CD, Anderson JL, Buller CE, Creager MA, Ettinger SM, Halperin JL, Hunt SA, Lytle BW, Nishimura R, Page RL, Riegel B, Tarkington LG, Yancy CW. 2007 Focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines: 2007 Writing Group to Review New Evidence and Update the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction, Writing on Behalf of the 2004 Writing Committee [published correction appears in *Circulation*. 2008;117:e162]. *Circulation*. 2008;117:296–329. doi: 10.1161/CIRCULATIONAHA.107.188209.
- Kushner FG, Hand M, Smith SC Jr, King SB 3rd, Anderson JL, Antman EM, Bailey SR, Bates ER, Blankenship JC, Casey DE Jr, Green LA, Hochman JS, Jacobs AK, Krumholz HM, Morrison DA, Ornato JP, Pearle DL, Peterson ED, Sloan MA, Whitlow PL, Williams DO. 2009 Focused updates: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines [published correction appears in *Circulation*. 2010;121:e257]. *Circulation*. 2009;120:2271–2306. doi: 10.1016/CIRCULATIONAHA.109.192663.
- Amsterdam EA, Wenger NK, Brindis RG, Casey DE Jr, Ganiats TG, Holmes DR Jr, Jaffe AS, Jneid H, Kelly RF, Kontos MC, Levine GN, Liebson PR, Mukherjee D, Peterson ED, Sabatine MS, Smalling RW, Zieman SJ. 2014 AHA/ACC guideline for the management of patients with non–ST-elevation acute coronary syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines [published correction appears in *Circulation*. 2014;130:e433–e434. *Circulation*. 2014;130:e344–e426. doi: 10.1161/CIR.0000000000000134.
- Alexander KP, Roe MT, Chen AY, Lytle BL, Pollack CV Jr, Foody JM, Boden WE, Smith SC Jr, Gibler WB, Ohman EM, Peterson ED; CRUSADE Investigators. Evolution in cardiovascular care for elderly patients with non-ST-segment elevation acute coronary syndromes: results from the CRUSADE National Quality Improvement Initiative. *J Am Coll Cardiol*. 2005;46:1479–1487. doi: 10.1016/j.jacc.2005.05.084.
- Avezum A, Makkisse F, Spencer F, Gore JM, Fox KA, Montalescot G, Eagle KA, White K, Mehta RH, Knobel E, Collet JP; GRACE Investigators. Impact of age on management and outcome of acute coronary syndrome: observations from the Global Registry of Acute Coronary Events (GRACE). *Am Heart J*. 2005;149:67–73. doi: 10.1016/j.ahj.2004.06.003.
- Fihn SD, Gardin JM, Abrams J, Berra K, Blankenship JC, Dallas AP, Douglas PS, Foody JM, Gerber TC, Hinderliter AL, King SB 3rd, Kligfield PD, Krumholz HM, Kwong RW, Lim MJ, Linderbaum JA, Mack MJ, Munger MA, Prager RL, Sabik JF, Shaw LJ, Sikkema JD, Smith CR Jr, Smith SC Jr, Spertus JA, Williams SV, Anderson JL. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons [published correction appears in *Circulation*. 2014;129:e463]. *Circulation*. 2012;126:e354–e471. doi: 10.1161/CIR.0b013e318277d6a0.
- Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, Chambers CE, Ellis SG, Guyton RA, Hollenberg SM, Khot UN, Lange RA, Mauri L, Mehran R, Moussa ID, Mukherjee D, Nallamothu BK, Ting HH. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions [published correction appears in *Circulation*. 2012;125:e412]. *Circulation*. 2011;124:e574–e651. doi: 10.1161/CIR.0b013e31823ba622.
- Singh M, Peterson ED, Roe MT, Ou FS, Spertus JA, Rumsfeld JS, Anderson HV, Klein LW, Ho KK, Holmes DR. Trends in the association between age and in-hospital mortality after percutaneous coronary intervention: National Cardiovascular Data Registry experience. *Circ Cardiovasc Interv*. 2009;2:20–26. doi: 10.1161/CIRCINTERVENTIONS.108.826172.
- Johnman C, Oldroyd KG, Mackay DF, Slack R, Pell AC, Flapan AD, Jennings KP, Eteiba H, Irving J, Pell JP. Percutaneous coronary intervention in the elderly: changes in case-mix and periprocedural outcomes in 31,758 patients treated between 2000 and 2007. *Circ Cardiovasc Interv*. 2010;3:341–345. doi: 10.1161/CIRCINTERVENTIONS.109.928705.
- Guagliumi G, Stone GW, Cox DA, Stuckey T, Tcheng JE, Turco M, Musumeci G, Griffin JJ, Lansky AJ, Mehran R, Grines CL, Garcia E.

- Outcome in elderly patients undergoing primary coronary intervention for acute myocardial infarction: results from the Controlled Abciximab and Device Investigation to Lower Late Angioplasty Complications (CADILLAC) trial. *Circulation*. 2004;110:1598–1604. doi: 10.1161/01.CIR.0000142862.98817.1F.
24. de Boer SP, Westerhout CM, Simes RJ, Granger CB, Zijlstra F, Boersma E; Primary Coronary Angioplasty Versus Thrombolysis-2 (PCAT-2) Trialists Collaborators Group. Mortality and morbidity reduction by primary percutaneous coronary intervention is independent of the patient's age. *JACC Cardiovasc Interv*. 2010;3:324–331. doi: 10.1016/j.jcin.2009.11.022.
 25. Hillis LD, Smith PK, Anderson JL, Bittl JA, Bridges CR, Byrne JG, Cigarroa JE, Disesa VJ, Hiratzka LF, Hutter AM Jr, Jessen ME, Keeley EC, Lahey SJ, Lange RA, London MJ, Mack MJ, Patel MR, Puskas JD, Sabik JF, Selnes O, Shahian DM, Trost JC, Winniford MD. 2011 ACCF/AHA guideline for coronary artery bypass graft surgery: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines [published correction appears in *Circulation*. 2011;124:e957]. *Circulation*. 2011;124:e652–e735. doi:10.1161/CIR.0b013e31823c074e.
 26. Society of Thoracic Surgeons website. Online STS Predicted Risk of Mortality or Major Morbidity. <http://riskcalc.sts.org/>. Accessed January 27, 2016.
 27. Jin R, Furnary AP, Fine SC, Blackstone EH, Grunkemeier GL. Using Society of Thoracic Surgeons risk models for risk-adjusting cardiac surgery results. *Ann Thorac Surg*. 2010;89:677–682. doi: 10.1016/j.athoracsur.2009.10.078.
 28. EuroSCORE II. <http://www.euroscore.org/calc.html>. Accessed January 27, 2016.
 29. Nashef SA, Roques F, Sharples LD, Nilsson J, Smith C, Goldstone AR, Lockowandt U. EuroSCORE II. *Eur J Cardiothorac Surg*. 2012;41:734–744. doi: 10.1093/ejcts/ezs043.
 30. Alexander KP, Anstrom KJ, Muhlbaier LH, Grosswald RD, Smith PK, Jones RH, Peterson ED. Outcomes of cardiac surgery in patients > or = 80 years: results from the National Cardiovascular Network. *J Am Coll Cardiol*. 2000;35:731–738.
 31. Yanagawa B, Algarni KD, Yau TM, Rao V, Brister SJ. Improving results for coronary artery bypass graft surgery in the elderly. *Eur J Cardiothorac Surg*. 2012;42:507–512. doi: 10.1093/ejcts/ezr300.
 32. Scott BH, Seifert FC, Grimsor R, Glass PS. Octogenarians undergoing coronary artery bypass graft surgery: resource utilization, postoperative mortality, and morbidity. *J Cardiothorac Vasc Anesth*. 2005;19:583–588. doi: 10.1053/j.jvca.2005.03.030.
 33. Bardakci H, Cheema FH, Topkara VK, Dang NC, Martens TP, Mercado ML, Forster CS, Benson AA, George I, Russo MJ, Oz MC, Esrig BC. Discharge to home rates are significantly lower for octogenarians undergoing coronary artery bypass graft surgery. *Ann Thorac Surg*. 2007;83:483–489. doi: 10.1016/j.athoracsur.2006.09.047.
 34. Engoren M, Arslanian-Engoren C, Steckel D, Neihardt J, Fenn-Buderer N. Cost, outcome, and functional status in octogenarians and septuagenarians after cardiac surgery. *Chest*. 2002;122:1309–1315.
 35. McClurken JB, Rosenhek R, Guy TS, Forman DE. Risk stratification in elderly coronary artery disease patients: can we predict which seniors benefit most from revascularization options? *Curr Cardiovasc Risk Rep*. 2011;5:422–431.
 36. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC Jr, Conti JB, Ellnor PT, Ezekowitz MD, Field ME, Murray KT, Sacco RL, Stevenson WG, Tchou PJ, Tracy CM, Yancy CW. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society [published correction appears in *Circulation*. 2014;130:e272–e274]. *Circulation*. 2014;130:e199–e267. doi: 10.1161/CIR.0000000000000041.
 37. Office of Information Products and Data Analytics CMMS. CMS administrative claims data, January 2011 - December 2011, From the Chronic Condition Warehouse. 2012. <http://www.ccwdata.org>. Accessed July 15, 2014.
 38. Calkins H, Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA, Crijns HJ, Damiano RJ Jr, Davies DW, DiMarco J, Edgerton J, Ellenbogen K, Ezekowitz MD, Haines DE, Haissaguerre M, Hindricks G, Iesaka Y, Jackman W, Jalife J, Jais P, Kalman J, Keane D, Kim YH, Kirchhof P, Klein G, Kottkamp H, Kumagai K, Lindsay BD, Mansour M, Marchlinski FE, McCarthy PM, Mont JL, Morady F, Nademanee K, Nakagawa H, Natale A, Nattel S, Packer DL, Pappone C, Prystowsky E, Raviele A, Reddy V, Ruskin JN, Shemin RJ, Tsao HM, Wilber D. 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design: a report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. *Heart Rhythm*. 2012;9:632–696.e21. doi: 10.1016/j.hrthm.2011.12.016.
 39. Bradley DJ, Shen WK. Atrioventricular junction ablation combined with either right ventricular pacing or cardiac resynchronization therapy for atrial fibrillation: the need for large-scale randomized trials. *Heart Rhythm*. 2007;4:224–232. doi: 10.1016/j.hrthm.2006.10.016.
 40. Chatterjee NA, Upadhyay GA, Ellenbogen KA, Hayes DL, Singh JP. Atrioventricular nodal ablation in atrial fibrillation: a meta-analysis of biventricular vs. right ventricular pacing mode. *Eur J Heart Fail*. 2012;14:661–667. doi: 10.1093/eurjhf/hfs036.
 41. Sanna T, Diener HC, Passman RS, Di Lazzaro V, Bernstein RA, Morillo CA, Rymer MM, Thijs V, Rogers T, Beckers F, Lindborg K, Brachmann J; CRYSTAL AF Investigators. Cryptogenic stroke and underlying atrial fibrillation. *N Engl J Med*. 2014;370:2478–2486. doi: 10.1056/NEJMoa1313600.
 42. Gladstone DJ, Spring M, Dorian P, Panzov V, Thorpe KE, Hall J, Vaid H, O'Donnell M, Laupacis A, Côté R, Sharma M, Blakely JA, Shuaib A, Hachinski V, Coutts SB, Sahlas DJ, Teal P, Yip S, Spence JD, Buck B, Verreault S, Casaubon LK, Penn A, Selchen D, Jin A, Howse D, Mehdiratta M, Boyle K, Aviv R, Kapral MK, Mamdani M; EMBRACE Investigators and Coordinators. Atrial fibrillation in patients with cryptogenic stroke. *N Engl J Med*. 2014;370:2467–2477. doi: 10.1056/NEJMoa1311376.
 43. Stroke Prevention in Atrial Fibrillation Risk Tool (SPARC). <http://sparc-tool.com>. Accessed January 27, 2016.
 44. Zipes DP, Camm AJ, Borggrefe M, Buxton AE, Chaitman B, Fromer M, Gregoratos G, Klein G, Moss AJ, Myerburg RJ, Priori SG, Quinones MA, Roden DM, Silka MJ, Tracy C, Smith SC Jr, Jacobs AK, Adams CD, Antman EM, Anderson JL, Hunt SA, Halperin JL, Nishimura R, Ornato JP, Page RL, Riegel B, Blanc JJ, Budaj A, Dean V, Deckers JW, Despres C, Dickstein K, Lekakis J, McGregor K, Metra M, Morais J, Osterspey A, Tamargo JL, Zamorano JL. ACC/AHA/ESC 2006 guidelines for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Develop Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death). *Circulation*. 2006;114:e385–e484. doi: 10.1161/CIRCULATIONAHA.106.178233.
 45. Epstein AE, DiMarco JP, Ellenbogen KA, Estes NA 3rd, Freedman RA, Gettes LS, Gillinov AM, Gregoratos G, Hammill SC, Hayes DL, Hlatky MA, Newby LK, Page RL, Schoenfeld MH, Silka MJ, Stevenson LW, Sweeney MO, Smith SC Jr, Jacobs AK, Adams CD, Anderson JL, Buller CE, Creager MA, Ettinger SM, Faxon DP, Halperin JL, Hiratzka LF, Hunt SA, Krumholz HM, Kushner FG, Lytle BW, Nishimura RA, Ornato JP, Page RL, Riegel B, Tarkington LG, Yancy CW. ACC/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices) [published correction appears in *Circulation*. 2009;120:e34–e35]. *Circulation*. 2008;117:e350–e408. doi: 10.1161/CIRCULATIONAHA.108.189742.
 46. Epstein AE, DiMarco JP, Ellenbogen KA, Estes NA 3rd, Freedman RA, Gettes LS, Gillinov AM, Gregoratos G, Hammill SC, Hayes DL, Hlatky MA, Newby LK, Page RL, Schoenfeld MH, Silka MJ, Stevenson LW, Sweeney MO. 2012 ACCF/AHA/HRS focused update incorporated into the ACCF/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. *Circulation*. 2013;127:e283–e352. doi: 10.1161/CIR.0b013e318276ce9b.
 47. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE, Jr., Drazner MH, Fonarow GC, Geraci SA, Horwich T, Januzzi JL, Johnson MR, Kasper EK, Levy WC, Masoudi FA, McBride PE, McMurray JJ, Mitchell JE, Peterson PN, Riegel B, Sam F, Stevenson LW, Tang WH, Tsai EJ, Wilkoff BL. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2013;128:e240–e327. doi: 10.1161/CIR.0b013e31829e8776.

48. Koplan BA, Epstein LM, Albert CM, Stevenson WG. Survival in octogenarians receiving implantable defibrillators. *Am Heart J*. 2006;152:714–719. doi: 10.1016/j.ahj.2006.06.008.
49. Lunney JR, Lynn J, Foley DJ, Lipson S, Guralnik JM. Patterns of functional decline at the end of life. *JAMA*. 2003;289:2387–2392. doi: 10.1001/jama.289.18.2387.
50. Lampert R, Hayes DL, Annas GJ, Farley MA, Goldstein NE, Hamilton RM, Kay GN, Kramer DB, Mueller PS, Padeletti L, Pozuelo L, Schoenfeld MH, Vardas PE, Wiegand DL, Zellner R; American College of Cardiology; American Geriatrics Society; American Academy of Hospice and Palliative Medicine; American Heart Association; European Heart Rhythm Association; Hospice and Palliative Nurses Association. HRS expert consensus statement on the management of cardiovascular implantable electronic devices (CIEDs) in patients nearing end of life or requesting withdrawal of therapy. *Heart Rhythm*. 2010;7:1008–1026. doi: 10.1016/j.hrthm.2010.04.033.
51. Mueller PS, Hook CC, Hayes DL. Ethical analysis of withdrawal of pacemaker or implantable cardioverter-defibrillator support at the end of life. *Mayo Clin Proc*. 2003;78:959–963. doi: 10.4065/78.8.959.
52. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP 3rd, Guyton RA, O’Gara PT, Ruiz CE, Skubas NJ, Sorajja P, Sundt TM 3rd, Thomas JD. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines [published corrections appear in *Circulation*. 2014;130:e120 and *Circulation*. 2014;129:e651]. *Circulation*. 2014;129:e521–e643. doi: 10.1161/CIR.0000000000000031.
53. Munt B, Legget ME, Kraft CD, Miyake-Hull CY, Fujioka M, Otto CM. Physical examination in valvular aortic stenosis: correlation with stenosis severity and prediction of clinical outcome. *Am Heart J*. 1999;137:298–306. doi: 10.1053/hj.1999.v137.95496.
54. Carroll JD, Carroll EP, Feldman T, Ward DM, Lang RM, McGaughey D, Karp RB. Sex-associated differences in left ventricular function in aortic stenosis of the elderly. *Circulation*. 1992;86:1099–1107.
55. Orsinelli DA, Aurigemma GP, Battista S, Krendel S, Gaasch WH. Left ventricular hypertrophy and mortality after aortic valve replacement for aortic stenosis: a high risk subgroup identified by preoperative relative wall thickness. *J Am Coll Cardiol*. 1993;22:1679–1683.
56. Kolh P, Kerzmann A, Honore C, Comte L, Limet R. Aortic valve surgery in octogenarians: predictive factors for operative and long-term results. *Eur J Cardiothorac Surg*. 2007;31:600–606. doi: 10.1016/j.ejcts.2007.01.003.
57. Leon MB, Smith CR, Mack M, Miller DC, Moses JW, Svensson LG, Tuzcu EM, Webb JG, Fontana GP, Makkar RR, Brown DL, Block PC, Guyton RA, Pichard AD, Bavaria JE, Herrmann HC, Douglas PS, Petersen JL, Akin JJ, Anderson WN, Wang D, Pocock S; PARTNER Trial Investigators. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. *N Engl J Med*. 2010;363:1597–1607. doi: 10.1056/NEJMoa1008232.
58. Kodali SK, Williams MR, Smith CR, Svensson LG, Webb JG, Makkar RR, Fontana GP, Dewey TM, Thourani VH, Pichard AD, Fischbein M, Szeto WY, Lim S, Greason KL, Teirstein PS, Malaisrie SC, Douglas PS, Hahn RT, Whisenant B, Zajarias A, Wang D, Akin JJ, Anderson WN, Leon MB; PARTNER Trial Investigators. Two-year outcomes after transcatheter or surgical aortic-valve replacement. *N Engl J Med*. 2012;366:1686–1695. doi: 10.1056/NEJMoa1200384.
59. Buellesfeld L, Gerckens U, Schuler G, Bonan R, Kovac J, Serruys PW, Labinaz M, den Heijer P, Mullen M, Tymchak W, Windecker S, Mueller R, Grube E. 2-Year follow-up of patients undergoing transcatheter aortic valve implantation using a self-expanding valve prosthesis. *J Am Coll Cardiol*. 2011;57:1650–1657. doi: 10.1016/j.jacc.2010.11.044.
60. Shroyer AL, Coombs LP, Peterson ED, Eiken MC, DeLong ER, Chen A, Ferguson TB Jr, Grover FL, Edwards FH. The Society of Thoracic Surgeons: 30-day operative mortality and morbidity risk models. *Ann Thorac Surg*. 2003;75:1856–1864.
61. Lindman BR, Bonow RO, Otto CM. Current management of calcific aortic stenosis. *Circ Res*. 2013;113:223–237. doi: 10.1161/CIRCRESAHA.111.300084.
62. Heidenreich PA, Albert NM, Allen LA, Bluemke DA, Butler J, Fonarow GC, Ikonomicis JS, Khavjou O, Konstam MA, Maddox TM, Nichol G, Pham M, Piña IL, Trogdon JG; on behalf of the American Heart Association Advocacy Coordinating Committee; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular Radiology and Intervention; Council on Clinical Cardiology; Council on Epidemiology and Prevention; Stroke Council. Forecasting the impact of heart failure in the United States: a policy statement from the American Heart Association. *Circ Heart Fail*. 2013;6:606–619. doi: 10.1161/HHF.0b013e318291329a.
63. Peura JL, Colvin-Adams M, Francis GS, Grady KL, Hoffman TM, Jessup M, John R, Kiernan MS, Mitchell JE, O’Connell JB, Pagni FD, Petty M, Ravichandran P, Rogers JG, Semigran MJ, Toole JM; on behalf of the American Heart Association Heart Failure and Transplantation Committee of the Council on Clinical Cardiology; Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation; Council on Cardiovascular Disease in the Young; Council on Cardiovascular Nursing; Council on Cardiovascular Radiology and Intervention, and Council on Cardiovascular Surgery and Anesthesia. Recommendations for the use of mechanical circulatory support: device strategies and patient selection: a scientific statement from the American Heart Association. *Circulation*. 2012;126:2648–2667. doi: 10.1161/CIR.0b013e3182769a54.
64. Temel JS, Greer JA, Muzikansky A, Gallagher ER, Admane S, Jackson VA, Dahlin CM, Blinderman CD, Jacobsen J, Pirl WF, Billings JA, Lynch TJ. Early palliative care for patients with metastatic non-small-cell lung cancer. *N Engl J Med*. 2010;363:733–742. doi: 10.1056/NEJMoa1000678.
65. Allen LA, Stevenson LW, Grady KL, Goldstein NE, Matlock DD, Arnold RM, Cook NR, Felker GM, Francis GS, Hauptman PJ, Havranek EP, Krumholz HM, Mancini D, Riegel B, Spertus JA; on behalf of the American Heart Association; Council on Quality of Care and Outcomes Research; Council on Cardiovascular Nursing; Council on Clinical Cardiology; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Surgery and Anesthesia. Decision making in advanced heart failure: a scientific statement from the American Heart Association. *Circulation*. 2012;125:1928–1952. doi: 10.1161/CIR.0b013e31824f2173.
66. Paulus WJ, Tschöpe C. A novel paradigm for heart failure with preserved ejection fraction: comorbidities drive myocardial dysfunction and remodeling through coronary microvascular endothelial inflammation. *J Am Coll Cardiol*. 2013;62:263–271. doi: 10.1016/j.jacc.2013.02.092.
67. Green P, Maurer MS, Foody JM, Forman DE, Wenger NK. Representation of older adults in the late-breaking clinical trials American Heart Association 2011 Scientific Sessions. *J Am Coll Cardiol*. 2012;60:869–871. doi: 10.1016/j.jacc.2012.03.034.
68. Allen LA, Hernandez AF, Peterson ED, Curtis LH, Dai D, Masoudi FA, Bhatt DL, Heidenreich PA, Fonarow GC. Discharge to a skilled nursing facility and subsequent clinical outcomes among older patients hospitalized for heart failure. *Circ Heart Fail*. 2011;4:293–300. doi: 10.1161/CIRCHEARTFAILURE.110.959171.
69. Hirsch AT, Haskal ZJ, Hertzer NR, Bakal CW, Creager MA, Halperin JL, Hiratzka LF, Murphy WR, Olin JW, Puschett JB, Rosenfield KA, Sacks D, Stanley JC, Taylor LM Jr, White CJ, White J, White RA. ACC/AHA 2005 practice guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease). *Circulation*. 2006;113:e463–e654. doi: 10.1161/CIRCULATIONAHA.106.174526.
70. Rooke TW, Hirsch AT, Misra S, Sidawy AN, Beckman JA, Findeiss LK, Golzarian J, Gornik HL, Halperin JL, Jaff MR, Moneta GL, Olin JW, Stanley JC, White CJ, White JV, Zierler RE. 2011 ACCF/AHA focused update of the guideline for the management of patients with peripheral artery disease (updating the 2005 guideline): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2011;124:2020–2045. doi: 10.1161/CIR.0b013e31822e80c3.
71. Boyd CM, Darer J, Boulton C, Fried LP, Boulton L, Wu AW. Clinical practice guidelines and quality of care for older patients with multiple comorbid diseases: implications for pay for performance. *JAMA*. 2005;294:716–724. doi: 10.1001/jama.294.6.716.
72. Morgenstern LB, Hemphill JC 3rd, Anderson C, Becker K, Broderick JP, Connolly ES Jr, Greenberg SM, Huang JN, MacDonald RL, Messé SR, Mitchell PH, Selim M, Tamargo RJ; on behalf of the American Heart Association Stroke Council and Council on Cardiovascular Nursing. Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2010;41:2108–2129. doi: 10.1161/STR.0b013e3181ec611b.
73. Brott TG, Halperin JL, Abbara S, Bacharach JM, Barr JD, Bush RL, Cates CU, Creager MA, Fowler SB, Friday G, Hertzberg VS, McIlff EB, Moore WS, Panagos PD, Riles TS, Rosenwasser RH, Taylor

- AJ. 2011 ASA/ACCF/AHA/AANN/AANS/ACR/ASNR/CNS/SAIP/SCAI/SIR/SNIS/SVM/SVS guideline on the management of patients with extracranial carotid and vertebral artery disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American Stroke Association, American Association of Neuroscience Nurses, American Association of Neurological Surgeons, American College of Radiology, American Society of Neuroradiology, Congress of Neurological Surgeons, Society of Atherosclerosis Imaging and Prevention, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, Society of NeuroInterventional Surgery, Society for Vascular Medicine, and Society for Vascular Surgery [published corrections appear in *Circulation*. 2011;124:e146 and *Circulation*. 2012;126:e26]. *Circulation*. 2011;124:e54–e130. doi: 10.1161/CIR.0b013e31820d8c98.
74. Goldstein LB, Bushnell CD, Adams RJ, Appel LJ, Braun LT, Chaturvedi S, Creager MA, Culebras A, Eckel RH, Hart RG, Hinchey JA, Howard VJ, Jauch EC, Levine SR, Meschia JF, Moore WS, Nixon JV, Pearson TA; on behalf of the American Heart Association Stroke Council; Council on Cardiovascular Nursing; Council on Epidemiology and Prevention; Council for High Blood Pressure Research, Council on Peripheral Vascular Disease, and Interdisciplinary Council on Quality of Care and Outcomes Research. Guidelines for the primary prevention of stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association [published correction appears in *Stroke*. 2011;42:e26]. *Stroke*. 2011;42:517–584. doi: 10.1161/STR.0b013e3181fcb238.
 75. Gorelick PB, Scuteri A, Black SE, Decarli C, Greenberg SM, Iadecola C, Launer LJ, Laurent S, Lopez DL, Nyenhuis D, Petersen RC, Schneider JA, Tzourio C, Arnett DK, Bennett DA, Chui HC, Higashida RT, Lindquist R, Nilsson PM, Roman GC, Selkoe FW, Seshadri S; on behalf of the American Heart Association Stroke Council, Council on Epidemiology and Prevention, Council on Cardiovascular Nursing, Council on Cardiovascular Radiology and Intervention, and Council on Cardiovascular Surgery and Anesthesia. Vascular contributions to cognitive impairment and dementia: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2011;42:2672–2713. doi: 10.1161/STR.0b013e3182299496.
 76. Connolly ES Jr, Rabinstein AA, Carhuapoma JR, Derdeyn CP, Dion J, Higashida RT, Hoh BL, Kirkness CJ, Naidech AM, Ogilvy CS, Patel AB, Thompson BG, Vespa P; on behalf of the American Heart Association Stroke Council; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; Council on Cardiovascular Surgery and Anesthesia; Council on Clinical Cardiology. Guidelines for the management of aneurysmal subarachnoid hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2012;43:1711–1737. doi: 10.1161/STR.0b013e3182587839.
 77. Furie KL, Goldstein LB, Albers GW, Khatri P, Neyens R, Turakhia MP, Turan TN, Wood KA; on behalf of the American Heart Association Stroke Council; Council on Quality of Care and Outcomes Research; Council on Cardiovascular Nursing; Council on Clinical Cardiology; Council on Peripheral Vascular Disease. Oral antithrombotic agents for the prevention of stroke in nonvalvular atrial fibrillation: a science advisory for healthcare professionals from the American Heart Association/American Stroke Association [published corrections appear in *Stroke*. 2013;44:e20 and *Stroke*. 2012;43:e181]. *Stroke*. 2012;43:3442–3453. doi: 10.1161/STR.0b013e318266722a.
 78. Jauch EC, Saver JL, Adams HP Jr, Bruno A, Connors JJ, Demaerschalk BM, Khatri P, McMullan PW Jr, Qureshi AI, Rosenfield K, Scott PA, Summers DR, Wang DZ, Wintermark M, Yonas H; on behalf of the American Heart Association Stroke Council; Council on Cardiovascular Nursing; Council on Peripheral Vascular Disease; Council on Clinical Cardiology. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013;44:870–947. doi: 10.1161/STR.0b013e318284056a.
 79. Bushnell C, McCullough LD, Awad IA, Chireau MV, Fedder WN, Furie KL, Howard VJ, Lichtman JH, Lisabeth LD, Piña IL, Reeves MJ, Rexrode KM, Saposnik G, Singh V, Towfighi A, Vaccarino V, Walters MR; on behalf of the American Heart Association Stroke Council; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Epidemiology and Prevention; Council for High Blood Pressure Research. Guidelines for the prevention of stroke in women: a statement for healthcare professionals from the American Heart Association/American Stroke Association [published corrections appear in *Stroke*. 2014;45:e95 and *Stroke*. 2014;45:e214]. *Stroke*. 2014;45:1545–1588. doi: 10.1161/01.str.0000442009.06663.48.
 80. Holloway RG, Arnold RM, Creutzfeldt CJ, Lewis EF, Lutz BJ, McCann RM, Rabinstein AA, Saposnik G, Sheth KN, Zahuranec DB, Zipfel GJ, Zorowitz RD; on behalf of the American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, and Council on Clinical Cardiology. Palliative and end-of-life care in stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:1887–1916. doi: 10.1161/STR.0000000000000015.
 81. Kernan WN, Ovbiagele B, Black HR, Bravata DM, Chimowitz MI, Ezekowitz MD, Fang MC, Fisher M, Furie KL, Heck DV, Johnston SC, Kasner SE, Kittner SJ, Mitchell PH, Rich MW, Richardson D, Schwamm LH, Wilson JA; on behalf of the American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, Council on Clinical Cardiology, and Council on Peripheral Vascular Disease. Guidelines for the prevention of stroke in patients with stroke and transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:2160–2236. doi: 10.1161/STR.0000000000000024.
 82. Wijedicks EF, Sheth KN, Carter BS, Greer DM, Kasner SE, Kimberly WT, Schwab S, Smith EE, Tamargo RJ, Wintermark M; on behalf of the American Heart Association Stroke Council. Recommendations for the management of cerebral and cerebellar infarction with swelling: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:1222–1238. doi: 10.1161/01.str.0000441965.15164.d6.
 83. Sandercock P, Wardlaw JM, Lindley RI, Dennis M, Cohen G, Murray G, Innes K, Venables G, Czlonkowska A, Kobayashi A, Ricci S, Murray P, Berge E, Slot KB, Hankey GJ, Correia M, Peeters A, Matz K, Lyrrer P, Gubitz G, Phillips SJ, Arauz A. The benefits and harms of intravenous thrombolysis with recombinant tissue plasminogen activator within 6 h of acute ischaemic stroke (the Third International Stroke Trial [IST-3]): a randomised controlled trial [published correction appears in *Lancet*. 2012;380:730]. *Lancet*. 2012;379:2352–2363.
 84. Jüttler E, Unterberg A, Woitzik J, Bösel J, Amiri H, Sakowitz OW, Gondan M, Schiller P, Limprecht R, Luntz S, Schneider H, Pinzer T, Hobohm C, Meixensberger J, Hacke W; DESTINY II Investigators. Hemispherectomy in older patients with extensive middle-cerebral-artery stroke. *N Engl J Med*. 2014;370:1091–1100. doi: 10.1056/NEJMoal1311367.
 85. Mendelow AD, Gregson BA, Rowan EN, Murray GD, Gholkar A, Mitchell PM; STICH II Investigators. Early surgery versus initial conservative treatment in patients with spontaneous supratentorial lobar intracerebral haematomas (STICH II): a randomised trial [published correction appears in *Lancet*. 2013;382:396]. *Lancet*. 2013;382:397–408. doi: 10.1016/S0140-6736(13)60986-1.
 86. Fleisher LA, Fleischmann KE, Auerbach AD, Barnason SA, Beckman JA, Bozkurt B, Davila-Roman VG, Gerhard-Herman MD, Holly TA, Kane GC, Marine JE, Nelson MT, Spencer CC, Thompson A, Ting HH, Uretsky BF, Wijesundera DN. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;130:e278–e333. doi: 10.1161/CIR.0000000000000106.
 87. Finlayson EV, Birkmeyer JD. Operative mortality with elective surgery in older adults [published correction appears in *Eff Clin Pract*. 2001;4:235]. *Eff Clin Pract*. 2001;4:172–177.
 88. Birkmeyer JD, Siewiers AE, Finlayson EV, Stukel TA, Lucas FL, Batista I, Welch HG, Wennberg DE. Hospital volume and surgical mortality in the United States. *N Engl J Med*. 2002;346:1128–1137. doi: 10.1056/NEJMs012337.
 89. American Geriatrics Society Expert Panel on the Care of Older Adults with Multimorbidity. Guiding principles for the care of older adults with multimorbidity: an approach for clinicians. *J Am Geriatr Soc*. 2012;60:E1–E25. doi: 10.1111/j.1532-5415.2012.04188.x.
 90. Cohen ME, Ko CY, Bilimoria KY, Zhou L, Huffman K, Wang X, Liu Y, Kraemer K, Meng X, Merkow R, Chow W, Matel B, Richards K, Hart AJ, Dimick JB, Hall BL. Optimizing ACS NSQIP modeling for evaluation of surgical quality and risk: patient risk adjustment, procedure mix adjustment, shrinkage adjustment, and surgical focus. *J Am Coll Surg*. 2013;217:336–346.e1. doi: 10.1016/j.jamcollsurg.2013.02.027.
 91. Gupta PK, Gupta H, Sundaram A, Kaushik M, Fang X, Miller WJ, Esterbrooks DJ, Hunter CB, Pipinos II, Johanning JM, Lynch TG, Forse RA, Mohiuddin SM, Mooss AN. Development and validation of

- a risk calculator for prediction of cardiac risk after surgery. *Circulation*. 2011;124:381–387. doi: 10.1161/CIRCULATIONAHA.110.015701.
92. Hemphill JC 3rd, Greenberg SM, Anderson CS, Becker K, Bendok BR, Cushman M, Fung GL, Goldstein JN, Macdonald RL, Mitchell PH, Scott PA, Selim MH, Woo D; on behalf of the American Heart Association Stroke Council; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology. Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2015;46:2032–2060. doi: 10.1161/STR.0000000000000069.
93. Meschia JF, Bushnell C, Boden-Albala B, Braun LT, Bravata DM, Chaturvedi S, Creager MA, Eckel RH, Elkind MS, Fornage M, Goldstein LB, Greenberg SM, Horvath SE, Iadecola C, Jauch EC, Moore WS, Wilson JA; on behalf of the American Heart Association Stroke Council; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Functional Genomics and Translational Biology; Council on Hypertension. Guidelines for the primary prevention of stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:3754–3832. doi: 10.1161/STR.0000000000000046.

Knowledge Gaps in Cardiovascular Care of the Older Adult Population: A Scientific Statement From the American Heart Association, American College of Cardiology, and American Geriatrics Society

Michael W. Rich, Deborah A. Chyun, Adam H. Skolnick, Karen P. Alexander, Daniel E. Forman, Dalane W. Kitzman, Mathew S. Maurer, James B. McClurken, Barbara M. Resnick, Win K. Shen, David L. Tirschwell and on behalf of the American Heart Association Older Populations Committee of the Council on Clinical Cardiology, Council on Cardiovascular and Stroke Nursing, Council on Cardiovascular Surgery and Anesthesia, and Stroke Council; American College of Cardiology; and American Geriatrics Society on behalf of the American Heart Association Older Populations Committee of the Council on Clinical Cardiology, Council on Cardiovascular and Stroke Nursing, Council on Cardiovascular Surgery and Anesthesia, and Stroke Council; American College of Cardiology; and American Geriatrics Society

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