Background

Since their initial clinical demonstration in 1980, implantable cardioverter–defibrillators (ICDs) have prolonged countless lives with successful treatment of sudden cardiac arrest.1 No other therapy has proved as effective in preventing death from ventricular arrhythmias, and important advances in ICD technology continue to improve outcomes for well-selected patients.2 Although indicated for a wide range of inherited and acquired conditions,3 ICDs are predominantly placed in older patients with left ventricular systolic dysfunction and either previous myocardial infarction or congestive heart failure.4 In the United States alone, >50,000 ICDs are placed annually in patients aged >65 years, and nearly 500,000 more may meet current guidelines for device implantation.5

However, decision making for older patients considering ICD implantation is particularly challenging. Subjects in the landmark trials had average ages in the 60s, and thus the survival benefits of ICDs in older age groups is less well-established.6 In addition, compared with the younger participants in most clinical trials, older adults have a lower ratio of arrhythmic death to nonarrhythmic death because of competing risks for mortality, resulting in a potentially lower absolute risk reduction. At the same time, living and eventually dying with an ICD introduces potential risks, including a lower quality of life (QoL), hospitalizations, and potential suffering at the end of life.7 A rigorous consideration of the benefits, risks, and ongoing care surrounding ICD use in older patients is long overdue.

On April 22, 2014, we convened a conference of multidisciplinary experts in cardiac electrophysiology, heart failure, geriatrics, ethics, and palliative care in Boston, supported by the Hartford Change AGEnts and Paul B. Beeson Career Development Award programs, and the Hebrew SeniorLife Institute for Aging Research. The objectives of the conference were (1) to review what is currently known about ICD use in older patients: epidemiology, clinical outcomes, cardiac resynchronization therapy (CRT), health status evaluation, decision support, palliative care, and ethics; (2) identify research priorities for the field; and (3) define opportunities for immediate practice improvement. Participants presented lectures summarizing the current evidence and proposing key research gaps needed to better select and support older patients for ICD treatment. Summary conclusions were discussed and debated collectively. This article summarizes the discussion and conclusions of this symposium. Although not intended as a complete review of the literature, this proceedings summary may serve to orient the clinical community toward the most pressing clinical and research problems while suggesting a roadmap for improvement.

Current Knowledge

Epidemiology

ICD use remained relatively limited until the early 2000s. Estimates in the United States derived from the National Inpatient Sample described annual implantation rates of 25,000 to 50,000 in the years 1997 to 2001, with few CRT-D implants before 2002.8 However, advances in transvenous ICD lead design, publication of pivotal studies in primary prevention populations,9–11 and the advent of CRT12,13 supported dramatic increases in ICD use.14 Data from the National Cardiovascular Data Registry (NCDR)—ICD Registry provides the most comprehensive...
recent assessment of ICD use in the United States. In 2011, there were 175,000 implantations entered in the ICD Registry, of which 75% were aged >60 years, 50% were aged >70 years, and nearly 20% were aged >80 years. Importantly, nearly 40% of all procedures were ICD generator replacements. A separate US registry similarly demonstrated >40% of new implantations in patients aged >70 years, and >12% aged >80 years. Data from registries outside the United States clearly illustrate that the use of ICDs in older patients is an international challenge. For example, >40% of ICDs in an Ontario study were in patients aged >70 years,10 and 25% in an Italian registry were aged >75 years.17

Among recipients of ICDs aged >60 years, 80% receive the ICD as primary prevention, that is, they have not previously experienced sudden cardiac arrest or sustained ventricular tachycardia.15,16 Of these, an estimated 75% meet indications for ICD implantation as defined by the inclusion criteria of the Sudden Cardiac Death in Heart Failure Trial (SCD-HeFT) study, which enrolled patients with a left ventricular ejection fraction of <35% and clinical heart failure.

Although, in theory, ICD implantation primarily serves to prevent sudden cardiac arrest, for which only a single-chamber device is necessary, a large proportion of implants involve either dual-chamber or CRT systems.18 Data from the ICD Registry demonstrate that a large percentage of patients without a clear indication for pacing nonetheless receive dual-chamber ICDs. There is considerable regional and hospital-level variation in this practice.19,20 Furthermore, 30% to 40% of ICD implants are CRT-D devices, implanted for improvement in heart failure symptoms, as well as mortality benefit. The highest proportion of such implants occurs in patients aged >80 years. The use of CRT systems without an ICD is less well-established, but seems to be less common than CRT-D implantation.8

Clinical Outcomes
Clinical trials and observational studies inform estimates of ICD effects on survival and QoL alongside procedural complications. Most clinical trials of ICD therapy enrolled patients with median ages in the 60s, and extrapolating data even from the few older patients represented in these studies to the real-world elderly is fraught with difficulty.21 Meta-analyses of pivotal trials in both primary prevention6 and secondary prevention22 populations, stratified according to age did not show a significant survival advantage for older patients (aged >65 or >75 years, respectively), although some of this difference may have been because of the smaller numbers of elderly patients enrolled. A separate pooled analysis of clinical trial data demonstrated a persistent survival advantage in older ICD recipients (with a hazard ratio for those aged 65–74 years of 0.67; 95% posterior credible interval, 0.53–0.85).23 Several nonrandomized studies have proposed that the survival advantage in older patients remains statistically and clinically significant. For example, propensity-matched evaluation of Medicare beneficiaries with heart failure and left ventricular systolic dysfunction demonstrated a significant survival advantage among those who received ICDs (hazard ratio, 0.71; 95% confidence interval, 0.56–0.91).24 This was similar to findings from a separate cohort study of US patients in which age alone was not a predictor of survival benefits.25 However, there remains substantial confounding in practice because of selection of healthier patients for ICD, who among the Medicare population had fewer subsequent hip fractures (hazard ratio, 0.77) and nursing home admissions (hazard ratio, 0.53) than patients not receiving ICDs.26 Other studies have indicated similar rates of appropriate shock among older and younger patients,27 despite the consistent finding of higher overall mortality with older age—with a higher proportion of deaths from causes other than sudden arrhythmic causes—and accumulated comorbidity in patients receiving both new and replacement ICDs.28–30

Acute complications seem to be slightly more common in older recipients of ICDs, although still relatively unusual: <2% overall, with each decade of age increasing this absolute risk by only 0.2% according to 1 estimate.31 Other analyses have similarly showed a gradient of risk with increasing age, largely driven by the accumulated comorbidities.32 However, these estimates are based largely on index admissions, and analyses exploring longer term complications may be as high as 10%.33

Given the frequent use of ICD therapy in older patients alongside concerns about survival and complication rates, several investigators have developed risk models for mortality after ICD implantation.34–39 Although the methods vary by study, in general these models illustrate the feasibility of risk-stratifying patients at the time of implant along a spectrum of 1-year mortality risk from as low as 3% to 40% or more depending on accumulated risk factors. Although age emerges as an independent risk factor for early mortality in these models, the consistent message across these studies is the important contribution of associated conditions such as renal dysfunction and atrial fibrillation as modifiers of the impact of age alone.

Fewer data inform outcomes and the benefits for older patients after ICD generator replacement, although ICD Registry data has shown a higher rate of death after replacement compared with initial implantation,26 with age independently increasing the hazard for death.29 Similarly, a small registry study illustrated that half of octogenarians receiving elective generator replacements died within 1 year postprocedure.40

Cardiac Resynchronization Therapy
Registry data described above clearly shows that CRT systems are commonly implanted in older patients, and account for a greater share of all ICD implants in older patient than in younger groups, including as much as 40% in those aged >80 years.15,41,42 As with ICDs, the clinical trials in severe heart failure12,13 and more mild heart failure43–45 did not exclude patients based on older age alone. Although the median age in the Comparison of Medical Therapy, Pacing, and Defibrillation in Heart Failure (COMPANION) and Cardiac Resynchronization-Heart Failure (CARE-HF) studies was 67 and 66 years respectively, the proportion of patients in either trial aged >80 years was not reported. Both studies provided only limited subgroup analyses of its older patients. In the 3 largest studies of mild heart failure, the mean age was 65 years and generally suggested trends toward benefits in the older subjects, although only Multicenter Automatic Defibrillator Implantation Trial with Cardiac Resynchronization Therapy
ICD Use in Older Adults

(MADIT-CRT) had sufficient power to demonstrate a statistically significant improvement in its composite end point (death or heart failure). Meta-analyses of CRT trials have not reported outcomes specifically in subjects >65 years.

Observational studies have suggested benefits in older patients in other important clinical end points, including QoL, as well as physiological and echocardiographic parameters. In sum, although definitive clinical trials just in older patients have not been performed, both CRT therapy alone and in concert with CRT seem to be effective in older patients according to prevention of arrhythmic death and (for CRT) improvement in QoL—but with important limitations posed by slightly increased risks of complications, substantial competing risks for nonsudden deaths, and attenuation of physiological benefits from cumulative comorbid conditions.

Measuring Health Status
ICDs and, particularly CRT-D devices may impact QoL, functional status, hospitalizations, and other outcomes apart from survival. Yet, to date, there is limited insight into the patient characteristics associated with greater or worse health status after device implantation. This creates a compelling need to understand the patient and treatment characteristics associated with patients’ self-reported health status after device-based therapy. Health status evaluation in cardiovascular patients aims to characterize several domains of patients’ experience and can leverage either generic or disease-specific tools. Although instruments vary, most include measures of symptoms, activity restrictions, psychological factors, and an assessment of patients’ overall self-perceived QoL. Several existing instruments can measure and track health status in patients eligible for ICD implantation, particularly those with heart failure. For example, the Kansas City Cardiomyopathy Questionnaire has been well-validated in a variety of contexts and predicts clinical outcomes, including in study cohorts with relatively old patients. Similarly, disease-specific instruments for patients with coronary artery disease have been developed and validated. In older ICD recipients, it has been suggested that general health considerations play a role in decision making. However, more formal integration of health status measurement into preimplant considerations, idiographic recommendations for courses of treatment, and outcomes assessment has not been performed and is a critical gap in existing knowledge.

QoL alone has been assessed to a limited extent in several clinical trials of ICD recipients. Compared with control patients receiving medical therapy, patients with ICDs overall had a similar QoL in SCD-HeFT, MADIT-II and Antiarrhythmics Versus Implantable Defibrillators (AVID) trial, worse QoL in coronary artery bypass graft (CABG)-Patch, and improved QoL in Canadian Implantable Defibrillator Study (CIDS).

However, predictors of QoL remain poorly understood, and older data are further limited by earlier generations of ICD technology, which included larger generators and less sophisticated measures for avoiding inappropriate shocks.

Decision Support
The epidemiology and outcomes data make it clear that ICD use in older patients is common, and yet deciding whether to get an ICD can be a difficult decision for anyone, and integrating options for CRT (with or without an ICD) markedly complicates this process. These decisions are even more difficult for older patients and demand an understanding of the relative importance of survival and QoL. For each patient, the decision for a patient with heart failure considering an ICD is frequently not between life and death but rather between accepting an ICD and having a potentially longer life with advancing heart failure or declining an ICD and having a potentially shorter life but retaining the opportunity to die quickly, and indeed even with an ICD a small risk of sudden death untreatable by the device remains. Recently, the American College of Cardiology/American Heart Association guidelines for heart failure were modified to specifically include language stating that this trade-off should be discussed. This is particularly urgent given the many studies now available providing opportunities to provide quantitative estimates for individual patients. As noted previously, several models describe the risks of 1-year mortality in ICD recipients, and a smaller group of studies include non-ICD control arms for comparison. These models have not, however, been prospectively validated and their role in clinical practice remains uncertain, even alongside pooled clinical trial data demonstrating a persistent, if attenuated, benefit of ICDs in older patients.

As noted earlier, although less well-studied, there are data available to provide prognostic information around ICD generator replacement as well.

Unfortunately, evidence on how decisions are actually being made suggests that patients are not appropriately involved or informed. A recent integrative review of 24 articles related to patients’ perceptions of ICD decision making identified a significant degree of misunderstanding about the risks, benefits, and trade-offs in ICD treatment. Patients often overestimate the benefits and underestimate the risks. One survey of patients demonstrated that they overestimate the benefits of ICDs by >400%. Another study demonstrated that patients reported learning of many of the risks after implantation. Importantly, a consistent theme of many of the studies in the integrative review was that many patients were unaware of the option to deactivate their ICDs, particularly critical point of knowledge for older patients who may have multiple comorbidities.

These misunderstandings may be a function of the way that decisions about ICDs are presented to patients. One study used standardized patients to explore 11 different cardiologists’ discussions with patients related to ICD decision making. The authors found a strongly paternalistic tone focused on the patient needing the device. Another study identified that physicians were frightened to tell the patients too many of the risks because they did not want them to make a bad decision. A survey of >1200 members of the American College of Cardiology noted that physicians rated guidelines and mortality data much higher than patient preferences or patient knowledge in their recommendations for ICDs.

This limited literature on ICD decision making suggests marked room for improvement on purely clinical grounds—that is, to improve patient selection and participation in the process of receiving and managing an ICD over time. One approach leveraging both article and video tools is under
inclusion of the ICDs specifically even when completed, has been a consistent finding in surveys.75,76 As such, ICD deactivation remains needlessly complex for many clinicians and surrogate decision makers. This is in stark contrast to other life-sustaining therapies, as shown in 1 survey in which physicians were overall (≈ 90%) self-rated as comfortable discussing treatment withdrawal in general, although less than half were comfortable discussing ICD deactivation.77 A recent detailed case series of 150 patients who had their ICD or pacemaker deactivated demonstrated that most deactivations occurred within 2 days of death.78 In only 1 of these patients was the device addressed in an advance directive. This lack of preparation meant that surrogates were responsible for over half of the deactivation decisions. Among a group of family members of deceased patients, only 27% reported actually having had a discussion about ICD deactivation before death.79

One important barrier to more effective advance care planning is physician knowledge and experience. Qualitative studies suggest that clinicians are uncomfortable with these discussions: as 1 physician stated, “That’s an end-of-life conversation, when you put them in, you’re having a life-prolonging conversation.”80,81,82 Although the majority feel it is important to disable the ICD in terminally ill patients,82,83,84 there was no consensus on who should have these discussions.81,84,85

Ethics of ICD Deactivation

Ideally, evolving healthcare goals in the face of advancing illness become integrated into advance directives or other vehicles for advance care planning. However, even under optimal circumstances hard questions may remain, leading to decision-making dilemmas. These dilemmas principally include conflicts over the ethical and legal status of ICD deactivation in isolation and in comparison with other therapies, circumstances and outcomes of ICD deactivation, and improvements to the informed consent process for ICDs and CRT.

A 2010 Heart Rhythm Society consensus statement on managing ICDs in patients nearing end of life or requesting withdrawal of therapy included an extended discussion of the ethical principles supporting ICD deactivation.87 This statement anchored the management of ICDs in longstanding moral and legal precedents establishing the right of patients to decline medical interventions or request their cessation.88,89 This right is grounded in the moral principle of autonomy, which in this context reflects the right of individuals to define and determine their own treatment goals and interventions. There is general consensus among ethicists that refusing or withdrawing medical therapy (including ICDs) are equivalent, and doing so is not euthanasia or physician-assisted suicide. However, multiple survey and focus group studies including patients, physicians, and nurses have demonstrated that many individuals view ICDs as morally different from, for example, cardiopulmonary resuscitation or mechanical ventilation.75,77,80 The underlying justification for these beliefs, however, despite the lack of a clear moral or legal foundation, remains unclear.90,91

Key Research Questions

Several of the most pressing areas of inquiry around ICD use in older patients involve implantation patterns, particularly the marked variability in dual-chamber use and the apparently high use of CRT-D in older patients. Specifically, defining the association between more detailed patient- and provider-level characteristics with ICD implants may provide insights toward how and why specific devices are selected, particularly when selecting patients for CRT-P versus CRT-D. In addition, ICD replacement patterns remain poorly understood,92 and almost nothing is known in particular about how frequently, why, and with what outcomes older patients choose to decline ICD replacement. Finally, although some commentary on ICD use in older patients suggests suspected overuse,93 understanding whether there are populations of otherwise healthy older patients who may benefit significantly from ICD implantation but are not offered ICDs—and what drives these decisions—may provide an important opportunity for usefully expanding the thoughtful application of ICDs.94,95

Similarly, although professional society guidelines assert that age alone should not be a contraindication to ICD implantation or replacement, refinement of patient selection toward those most likely to benefit remains an urgent public health priority.96 This may be particularly valuable for ICD replacement, around which no prospective clinical trial evidence yet exists.92 Strategies of ICD nonreplacement in patients who arrived at the end of ICD battery life having recovered left ventricular function, or those who have not previously received ICD shocks, have not been explored in detail. In addition, given the comparatively short battery life of CRT systems compared with other ICDs, understanding how decisions about replacement for older patients with CRT are made would benefit from further study.97,98

Importantly, many older individuals value QoL as much or more than survival, and the interaction between CRT and ICDs on each of these outcomes is complex. The limited data suggest an urgent need to better inform patients about the risks and actual expected benefits of ICD therapy. Older patients with ICDs also combine disease-specific health status concerns arising from their underlying cardiovascular
problems with complexities introduced by the device itself. Thus, whether any of the existing QoL and health status measurements adequately capture all of the relevant clinical, psychological, and psychosocial domains of importance for these patients remains uncertain.

Few studies have targeted seemingly simple questions: which patients want to share decisions? Given that there is likely a spectrum of patient preferences about involvement in decisions, how should decision support be structured to capture this variability? How should families, other surrogates, or other professionals (other medical specialists, clergy, social workers, nurses, etc.) be involved? What information would be most valuable to them in considering ICD treatment (survival, QoL outcomes, periprocedural risks), with a goal of helping patients to identify their goals and values and make a concordance decision? How should decision support be different between initial ICDs, replacement ICDs, and CRT-P versus CRT-D? How well do older patients understand the decisions they make? What are the patient, physician, and system barriers to promoting shared decision making? In short, although the legal and ethical frameworks supporting decision support are clear, the optimal strategies to actually improve decision making remains unknown.

Similarly, overcoming barriers to conversations about ICD management as patients reach the end of life is the central question challenging the ethics and palliative care considerations for older patients with ICDs. Patients and surrogates face predictable decisions, but the optimal way the care of the ICD and its complications should be incorporated into ongoing palliative and supportive care discussions for these patients requires further study. Indeed, palliative care is already a CMS requirement for destination left ventricular device therapy—and the same principles apply to ICDs. In particular, approaches to making patients aware of ICD deactivation before or at the time of implantation need exploration. This may, in part, depend on a clearer understanding of exactly why patients and providers persist in their perception of ICDs as morally distinct from other life-sustaining therapies. Whether these beliefs rest on legal or technical confusion, lack of familiarity with ICD deactivation compared with other treatments, or reflect other concerns will have important implications for improving the informed consent, decision-making, advance care planning, and—one hopes—outcomes for older patients with ICDs.

Opportunities for Immediate Practice Improvement

Despite these research gaps, the existing knowledge base in ICD therapy supports several immediate changes to current practice. Indeed, although developed with a focus on older patients, the suggestions described here readily apply to any patient considering ICD therapy whose clinical context supports a holistic assessment of prognosis, treatment goals, and preferences. These suggestions include the following changes to processes of care and support for individualization of care (Table).

1. Public reporting of heart failure outcomes should focus not only on rates of ICD implantation in eligible patients but also on quantifying the frequency of a high-quality discussion of ICD risks and benefits with patients meeting initial clinical criteria.

2. Include health status measures in the National Cardiovascular Data Registry—Implantable Cardioverter–Defibrillator registry case report form.

3. Society guidelines and practice standards should emphasize the need for individualization of ICD implantation decision making based on context, clinical status, and patient preferences.

4. Documentation of appropriate advance care planning related to future ICD deactivation for older patients with ICDs should become routine practice.

ICD indicates implantable cardioverter–defibrillator.

**Table.** Opportunities for Immediate Practice Improvement

<table>
<thead>
<tr>
<th>Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Public reporting of heart failure outcomes should focus not only on rates of ICD implantation in eligible patients but also on quantifying the frequency of a high-quality discussion of ICD risks and benefits with patients meeting initial clinical criteria.</td>
</tr>
<tr>
<td>2. Include health status measures in the National Cardiovascular Data Registry—Implantable Cardioverter–Defibrillator registry case report form.</td>
</tr>
<tr>
<td>3. Society guidelines and practice standards should emphasize the need for individualization of ICD implantation decision making based on context, clinical status, and patient preferences.</td>
</tr>
<tr>
<td>4. Documentation of appropriate advance care planning related to future ICD deactivation for older patients with ICDs should become routine practice.</td>
</tr>
</tbody>
</table>
collected, no validated health status measurement is included in the form—a missed opportunity for large-scale, real-world measurement of a critical clinical variable. Integration of a relatively simple, but robust, metric such as the newly introduced, 12-item Kansas City Cardiomyopathy Questionnaire, which takes ≈2 minutes for patients to complete and has recently been included in both the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) registry of left ventricular assist devices and the Trans-Valvular Therapeutics Registry. Collecting the health status of ICD recipients at the time of implantation and over time could be used to document changes in health status over time that could be used to generate estimates of health status benefits as a foundation for future shared medical decision-making tools, and as a means of comparing patient-level benefits across centers for quality assessment and improvement purposes.

3. Society guidelines and practice standards should emphasize the need for individualization of ICD implantation decision making based on context, clinical status, and patient preferences.

ICD implantation is an exquisitely preference-sensitive decision. This is particularly true for older adults given that the trade-offs become even more pronounced in the context of increased periprocedural risks, the decreased timeline for benefit, and evolving preferences about aggressiveness of care and mode of dying. Individualization by use of risk models,29,34,35 decision aids, and collaboration among specialists involved in each patient’s care may support a more tailored approach to ICD use.

4. Documentation of appropriate advance care planning for older patients with ICDs should become routine practice.

Current practice patterns and reimbursement standards for ICD implantation focus on indications and device selection, carefully reflected in periprocedure documentation. Expanding this to include advance care planning may also be the swiftest way to improve the frequency of advance care planning discussions before ICD implantation, as has been done with CMS requirements for left ventricular assist devices. ICDs are resuscitative devices, implanted in patients for whom prognostic models illustrate predictable decisions about ICD deactivation, generator replacement, and overall goals of care. This argues for higher clinical standards for advance care planning in these patients before implantation.104 Documentation of, for example, designation of a healthcare proxy, completion of an advance directive, other state-specific vehicles and description of patients’ preferences for ICD management, as standard practice has the potential to improve the end-of-life care of these patients in particular. Making this practice a condition for reimbursement would serve as a powerful incentive for providers, but even without this external requirement (which would face many practical obstacles), the field of electrophysiology can take a firm position on making advance care planning as routine as measuring left ventricular systolic function in patients eligible for ICDs.

Several potential barriers to these 4 proposed recommendations merit comment. Public reporting and primary data collection such as the ICD registry already struggle with limited resources. Changes to professional society guidelines tend to be gradual and largely focus on emerging clinical trial evidence. Providers may also balk at additional documentation layered onto an already ornate process for illustrating clinical necessity and conformance with reimbursement guidelines. However, there is a clear ethical imperative to improve the care of older patients considering ICD implantation and living with these devices. ICDs are clearly life-saving in well-selected older patients, yet necessarily engage patients in providers—recognized or not—in a therapeutic process that directly asks hard questions about quality and duration of life, goals of care, preferences, and priorities. Thoughtfully reorienting the application of device-based therapy away from mere alignment with clinical trials toward the patient-centered approach advocated for here has never been more urgent.

Conclusions

ICD use in older patients is certain to grow in the coming years. Aggressive pursuit of the research goals and practice changes identified here will help support use that is thoughtful, patient-centered, and compassionate.

Sources of Funding

This Symposium was supported, in part, by a Hartford Change AGEnts Award from the John A. Hartford Foundation. Dr Kramer is supported by a Paul B. Beeson Career Development Award in Aging Research (K23AG045963). Dr Matlock is supported by a Paul B. Beeson Career Development Award in Aging Research (K23AG040696). Dr Mitchell is supported by National Institutes of Health-National Institute of Aging K24AG033640.

Disclosures

Dr Lampert obtained research support from Medtronic, Boston Scientific, and St Jude Medical. Dr Reynolds received Consulting support from Medtronic. The other authors report no conflicts.

References


Key Words: end-of-life care ▪ ethics ▪ health policy and outcomes research ▪ implantable cardioverter–defibrillator
Implantable Cardioverter–Defibrillator Use in Older Adults: Proceedings of a Hartford Change AGEnts Symposium


Circ Cardiovasc Qual Outcomes. 2015;8:437-446; originally published online June 2, 2015; doi: 10.1161/CIRCOUTCOMES.114.001660

Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2015 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-7705. Online ISSN: 1941-7713

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circoutcomes.ahajournals.org/content/8/4/437

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Cardiovascular Quality and Outcomes can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation: Cardiovascular Quality and Outcomes is online at:
http://circoutcomes.ahajournals.org//subscriptions/