AJKD
Original Investigation

Trends in the Use and Outcomes of Implantable Cardioverter-Defibrillators in Patients Undergoing Dialysis in the United States

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Background: Sudden cardiac death constitutes the leading cause of death in patients receiving dialysis. Little is known about the trends in implantable cardioverter-defibrillator (ICD) use and the outcomes of such device placement.

Study Design: Retrospective cohort study.

Setting & Participants: US long-term dialysis patients who received an ICD in 1994-2006.

Predictors, Outcomes, & Measurements: ICD utilization rates and incident rates of all-cause mortality, device infections, and other device-related procedures were measured. We compared mortality between recipients and otherwise similar patients who did not receive such a device using high-dimensional propensity score matching. We also examined the associations of demographics, dialysis type, baseline comorbid conditions, cardiovascular events at the time of admission, and recent infection with the study outcomes.

Results: 9,528 patients received an ICD in 1994-2006, with >88% placed after 2000. Almost all ICD use in the 1990s was for secondary prevention, however, half the patients received ICDs for apparent primary prevention in 2006. Mortality rates after implantation were high (448 deaths/1,000 patient-years) and most deaths were cardiovascular. Postimplantation infection rates were high, especially in the first year after implantation (988 events/1,000 patient-years) and were predicted by diabetes and recent infection. Patients receiving ICDs for secondary prevention had an overall 14% (95% CI, 9%-19%) lower mortality risk compared with propensity-matched controls, but these benefits seemed to be restricted to the early postimplantation time.

Limitations: Lack of clinical data, especially for laboratory and heart function studies. Residual confounding by indication.

Conclusions: ICD use in dialysis patients is increasing, but rates of all-cause and cardiovascular mortality remain high in dialysis patients receiving these devices. Device infections are common, particularly in patients with recent infections. Randomized trials of ICDs are needed to determine the efficacy, safety, and risk-benefit ratio of these devices in dialysis patients.

Am J Kidney Dis. 58(3):409-417.

INDEX WORDS: End-stage renal disease (ESRD); dialysis; cardiovascular disease; arrhythmia; sudden death; defibrillator; automated implantable cardioverter-defibrillator (AICD).

Editorial, p. 338

End-stage renal disease (ESRD) is an increasingly common condition associated with a high risk of developing and dying of cardiovascular disease.[1] Although incidences of all cardiovascular events are high in individuals with ESRD, the risk of sudden death seems to be particularly increased. Most cardiovascular deaths in patients on dialysis therapy are attributed to sudden cardiac death, which accounts for approximately one-quarter of all deaths and two-thirds of cardiovascular deaths in this population.[1]

Whether this high risk of sudden cardiac death in the dialysis population can be decreased is uncertain. In selected patients, mostly without advanced kidney disease, the use of implantable cardioverter-defibrillators (ICDs) has been shown to prevent arrhythmic

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Received June 7, 2010. Accepted in revised form March 29, 2011. Originally published online June 13, 2011.

Because an author of this manuscript is an editor for AJKD, the peer-review and decision-making processes were handled entirely by an Associate Editor (Amit X. Garg, MD, MA, FRCPC, PhD, London Health Sciences Centre) who served as Acting Editor-in-Chief. Details of the journal's procedures for potential editor conflicts are given in the Editorial Policies section of the AJKD website.

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0272-6386/$36.00
doi:10.1053/j.ajkd.2011.03.026

death,[2,3] and cardiovascular guidelines recommend the use of ICDs for survivors of cardiac arrest, individuals with structural heart disease and an episode of sustained ventricular tachycardia, and the primary prevention of cardiac arrest in individuals with markedly decreased ejection fractions from either ischemic or nonischemic causes.[4] Although there is considerable interest in treating dialysis patients with ICDs,[5,6] whether their use should be extended broadly to the dialysis population is unclear. To our knowledge, no patients on dialysis therapy were included in the pivotal trials underlying the current guidelines. Furthermore, the advanced age of the dialysis population, the high incidence of death from stroke and noncardiovascular causes, and the high prevalence of electrolyte level abnormalities that may lead to defibrillation-resistant arrhythmia in dialysis patients raise important questions about the use of defibrillators in this population. Additional concerns about the use of defibrillators in dialysis patients are engendered by the high incidence of catheter-associated bacteremia and the need to preserve central veins for dialysis access in this group.[1,6]

Although randomized clinical trials are needed to provide definitive data, answers from such trials are unlikely in the near future. In the meantime, ICD use in the dialysis population has expanded rapidly,[7] and more precise estimates of outcomes after ICD placement in long-term dialysis patients are needed to more fully understand the risks and benefits of the increased use of ICDs in this high-risk population. To more fully elucidate the merits of ICDs in the dialysis population, we used the US Renal Data System (USRDS) database to analyze trends in ICD use, estimate rates and correlates of fatal and nonfatal outcomes in dialysis patients who received an ICD in 1994-2006, and compare outcomes in dialysis patients who did and did not receive defibrillators.

METHODS

Data Source and Study Cohort

Data were obtained from the USRDS. The USRDS contains detailed data for all patients in Medicare's ESRD program, including information for demographics, primary cause of ESRD, and clinical conditions, which is collected on the Medical Evidence Form (Centers for Medicare & Medicaid Services [CMS]-2728) at dialysis therapy initiation. In addition, the USRDS includes all Medicare Part A and B claims, which include information for diagnoses and procedures recorded for all hospitalizations and outpatient visits.

Within the USRDS population, we identified persons 21 years and older who received an automated ICD or cardiac resynchronization therapy defibrillator in 1994-2006. Implantations were identified based on the presence of an *International Classification of Diseases, Ninth Revision* (*ICD-9*) procedure code of 37.94 (automated ICD) or 00.51 (cardiac resynchronization therapy defibrillator). We restricted the analysis to the first device a patient received, excluding reimplantations. To ensure complete ascertainment of baseline conditions, we required that participants have Medicare as a primary payer on the implantation date and have been on dialysis therapy for at least 90 days before the implantation date.

Comparison Cohort

For selected comparisons of patients receiving an ICD for secondary prevention with otherwise similar patients who had not received such a device, but who were hospitalized with diagnosed cardiac arrest or ventricular arrhythmia, we used a high-dimensional propensity score approach.[8] This novel approach uses data-mining techniques from a large number of variables to automatically determine the best high-dimensional propensity score model for the exposure and outcome of study. For the purpose of this study, all prespecified variables (described next) and hundreds of individual diagnosis and procedure codes from patients' health care claims before the index hospitalization were considered as candidates for inclusion in the high-dimensional propensity score. It previously has been shown that high-dimensional propensity score approaches are able to achieve marginal improvements in confounding control compared with traditional propensity score methods. We chose a 1:4 match of ICD recipients and similar patients hospitalized for cardiac arrest or ventricular fibrillation/tachycardia who did not receive such a device.

Baseline Covariates

For each patient, we obtained demographic data (age, sex, and race) and cause of renal failure from the Medical Evidence Form. Dialysis modality was obtained from the treatment history file of the USRDS, and baseline conditions were identified based on the presence of 1 Part A diagnosis or 2 or more Part B diagnoses during the period before the hospital admission for defibrillator implantation. These included risk factors for mortality, including history of myocardial infarction, coronary revascularization, coronary heart disease, ischemic stroke or transient ischemic attack, congestive heart failure, cardiac arrest or ventricular fibrillation/tachycardia, atrial fibrillation, chronic obstructive lung disease, cancer, and diabetes. A history of infection defined as prior bacteremia, septicemia, or intravenous vancomycin use was assessed as a risk factor for future device infection. In addition to clinical history, we assessed events occurring during the hospitalization for device implantation, based on the presence of a relevant diagnosis or procedure code. These included myocardial infarction, coronary bypass, coronary revascularization, ventricular fibrillation/tachycardia, cardiac arrest, and congestive heart failure. We also defined the likely indication for ICD implantation as primary versus secondary prevention in accordance with standard clinical definitions: Secondary prevention was defined as a diagnosis for ventricular fibrillation/tachycardia or cardiac arrest during the index hospitalization. In the absence of cardiac arrest or ventricular fibrillation/tachycardia on the index admission, ICD implantations were defined as primary prevention.

Outcomes

Outcomes of interest were all-cause mortality, lead changes and removal, generator replacement, and infection. Mortality date and cause of death were extracted from the ESRD death notification (CMS-2746) form submitted by dialysis units to the USRDS. We defined 2 infection outcomes: a more specific outcome of device infection (*ICD-9* diagnosis of 996.61) and a broader outcome of presumably severe infection, including episodes coded as device infections, postoperative infections, bacteremia, septicemia, and all episodes in which patients received intravenous vancomycin. Device infections were validated further by requiring evidence of intravenous antibiotic use, hospitalization, device or lead removal