Utilization of Implantable Cardioverter-Defibrillators in Survivors of Cardiac Arrest in the United States From 1996 to 2001

Andrew Voigt, MD,* Rana Ezzeddine, PhD,* William Barrington, MD,* Ogundu Obiaha-Ngwu, MD,* Leonard I. Ganz, MD,* Barry London, MD, PhD,* Samir Saba, MD*

Pittsburgh, Pennsylvania

OBJECTIVES
We analyzed the incidence of implantable cardioverter-defibrillator (ICD) therapy in survivors of cardiac arrest (CA) in the U.S. from 1996 through 2001.

BACKGROUND
Cardiac arrest is a class I indication for ICD therapy. The current patterns of ICD utilization in survivors of CA have not been fully examined.

METHODS
We searched a representative sample of all hospital discharges for patients admitted with the primary diagnosis of CA who survived to hospital discharge. Patients with a concomitant diagnosis of acute myocardial infarction or previous ICD in situ were excluded.

RESULTS
From 1996 to 2001, 113,262 patients were admitted for CA. Of those, 63,745 (56.3%) did not survive to hospital discharge. Of the remaining 49,517 patients, 30.7% received an ICD before discharge, with a gradual increase in implantation rates from 1996 (23.6%) to 2001 (46.3%). Using logistic regression for the years 2000 and 2001, patients who were discharged without an ICD were older (odds ratio [OR] 0.93 for every 10-year increase in age, p < 0.001), more likely to be African American (OR 0.19, p < 0.001), and more likely to be admitted to a smaller hospital (OR 2.24 for each additional 100 beds, p < 0.001). These predictors were independent of other co-morbid illnesses.

CONCLUSIONS
Although they are increasing, the rates of ICD therapy after CA remain very low. There are gross discrepancies by race. At a time when newer indications for ICD implantation are emerging, efforts should be focused on identifying the causes of this underutilization and discrepancies in survivors of CA. (J Am Coll Cardiol 2004;44:855–8) © 2004 by the American College of Cardiology Foundation

Utilization of Implantable Cardioverter-Defibrillators in Survivors of Cardiac Arrest in the United States From 1996 to 2001

Andrew Voigt, MD,* Rana Ezzeddine, PhD,* William Barrington, MD,* Ogundu Obiaha-Ngwu, MD,* Leonard I. Ganz, MD,* Barry London, MD, PhD,* Samir Saba, MD*

Pittsburgh, Pennsylvania

OBJECTIVES
We analyzed the incidence of implantable cardioverter-defibrillator (ICD) therapy in survivors of cardiac arrest (CA) in the U.S. from 1996 through 2001.

BACKGROUND
Cardiac arrest is a class I indication for ICD therapy. The current patterns of ICD utilization in survivors of CA have not been fully examined.

METHODS
We searched a representative sample of all hospital discharges for patients admitted with the primary diagnosis of CA who survived to hospital discharge. Patients with a concomitant diagnosis of acute myocardial infarction or previous ICD in situ were excluded.

RESULTS
From 1996 to 2001, 113,262 patients were admitted for CA. Of those, 63,745 (56.3%) did not survive to hospital discharge. Of the remaining 49,517 patients, 30.7% received an ICD before discharge, with a gradual increase in implantation rates from 1996 (23.6%) to 2001 (46.3%). Using logistic regression for the years 2000 and 2001, patients who were discharged without an ICD were older (odds ratio [OR] 0.93 for every 10-year increase in age, p < 0.001), more likely to be African American (OR 0.19, p < 0.001), and more likely to be admitted to a smaller hospital (OR 2.24 for each additional 100 beds, p < 0.001). These predictors were independent of other co-morbid illnesses.

CONCLUSIONS
Although they are increasing, the rates of ICD therapy after CA remain very low. There are gross discrepancies by race. At a time when newer indications for ICD implantation are emerging, efforts should be focused on identifying the causes of this underutilization and discrepancies in survivors of CA. (J Am Coll Cardiol 2004;44:855–8) © 2004 by the American College of Cardiology Foundation

Cardiac arrests (CAs) claim the lives of an estimated 340,000 people each year in the U.S. (1). The most common cause of CA is ventricular fibrillation (VF). Survival for out-of-hospital CA victims is abysmal and inversely proportional to the time to defibrillation (2). The implantable cardioverter-defibrillator (ICD) was developed to shorten the time to life-saving therapy from minutes to seconds. Survivors of VF arrest are at high risk of fatal arrhythmia recurrence (3).

Several large, prospective trials have demonstrated the superiority of ICD over anti-arrhythmic therapy in secondary prevention of CA (4–6). On the basis of this evidence, CA in the absence of a reversible cause is now a class I indication for ICD therapy (7).

Despite its widespread acceptance, evidence suggests that the ICD is underutilized in CA survivors in many Western nations. Implantation rates vary widely between industrialized countries, although rates of CA are similar (8–10). Also, demographic factors pertaining to race (11), gender (12), and age (13) have been shown to affect the rates of performance of invasive cardiac procedures in CA survivors.

We analyzed a nationally representative data base to evaluate trends in ICD utilization among CA survivors in the U.S. from 1996 through 2001. We also examined the influence of such factors as age, race, gender, and hospital size on implantation rates in this population.

METHODS
Data source. The National Hospital Discharge Survey (NHDS) collects data on ~1% of all discharges from U.S. nonfederal hospitals. Public use files include demographic data, seven diagnostic codes from the International Classification of Diseases-Ninth Revision-Clinical Modification (ICD-9-CM), four procedural codes, dates of hospital admission and release, sources of payment, and disposition at discharge. We collected these files from 1996 through 2001.

Diagnoses and procedures. The NHDS records from 1996 to 2001 were reviewed, and cases with VF (ICD-9-CM code 427.41), ventricular flutter (code 427.42), or CA (code 427.5) as a primary discharge diagnosis were selected. Patients with a previous defibrillator (codes 37.97, 37.98, and 37.99) or with a secondary diagnosis of acute transmural myocardial infarction (MI) (codes 410.11, 410.41, 410.51, and 410.61) were excluded. The procedure of interest included implantation of a new defibrillator (codes 37.94, 37.95, and 37.96) in patients who survived to hospital discharge.

Co-morbid conditions affecting surveyed patients were defined by their ICD-9-CM codes from the secondary
RESULTS

A review of discharges of over 212 million hospitalizations in the U.S. from 1996 through 2001 identified 115,361 admissions with a primary diagnosis of VF, ventricular flutter, or CA. Of these patients, 2,099 were excluded due to concurrent acute MI or previous defibrillator implantation. Of this cohort of 113,262 patients, 63,745 (56.3%) did not survive to hospital discharge. Patients who did not specify their racial background were excluded from the calculation of race-specific rates, but were included in all other calculations. A p value of <0.05 was considered statistically significant.

Utilization of ICD therapy. Of the remaining 49,517 patients who survived to hospital discharge, 15,189 (30.7%) received an ICD before discharge. Implantation rates increased gradually and significantly (p < 0.001) from 23.6% in 1996 to 46.3% in 2001.

African Americans were significantly (p < 0.001) less likely than Caucasians to receive an ICD after surviving an episode of CA, with 8.7% of blacks undergoing ICD implantation before hospital discharge, compared with 30.9% of whites (Fig. 1). This racial gap between white and black survivors of CA in the utilization of ICD therapy remained apparent over the study period of 1996 to 2001, but seemed to be closing as more black patients were receiving an ICD (29.2% in 2001 vs. 7.7% in 1996). The change between 1996 and 2001 in the utilization of the ICD represents an increase of 2.8-fold (280%) in the black compared with 78% in the white population. Because of their small sample size, patients of other racial backgrounds such as American Indians and Asians were not included in this analysis. Of note, 20.6% of patients admitted with a primary diagnosis of CA did not specify their racial background and were therefore also excluded from this analysis.

Between 1996 and 2001, women were more likely than men to be discharged home without an ICD after surviving CA (Fig. 2). During the study period, 4,693 (23.6%) of 19,848 women and 10,496 (35.4%) of 29,669 males received an ICD. Unlike racial disparities, gender differences were not persistently present throughout the study period and disappeared by the year 2001, where the rates of ICD implantation were actually higher in women (61.8%) compared with men (36.1%). The gender gap in the utilization of ICDs was present across racial boundaries, except among African Americans (p < 0.001 for whites, p = 0.030 for patients of other races, and p = NS for blacks when comparing the rates of ICD implantation in women vs. men). It is important to note that this gender discrepancy seems to have disappeared in the more recent years of the survey.

Patients discharged from smaller compared with larger hospitals were less likely to receive ICD therapy, with rates of ICD therapy ranging from 0% in very small hospitals (6 to 99 beds) to 56% in large hospitals (500+ beds). It is worth noting that the 0% rate of ICD in survivors of CA from the smallest hospitals might reflect the fact that these hospitals lack the ability to provide this service to their patients. Of note, however, is the fact that patients transferred to larger facilities to undergo ICD placement are
surveyed when discharged from these larger facilities and are not included in the statistics of the smaller hospitals. The frequencies of major co-morbid illnesses in the survivors of CA were also analyzed in the study population and compared across racial boundaries. Compared with white survivors of CA, black patients had a lower prevalence of metabolic acidosis (0% vs. 2.2%) and cardiovascular failure (0% vs. 2.8%), but had a higher incidence of respiratory failure (44% vs. 31%), renal failure (8.2% vs. 1.2%), and neurologic failure (28% vs. 22%). There were no race differences in the frequencies of hepatic failure (0%) or hematologic abnormalities (0.7%).

Using binary logistic regression analysis for the years 2000 and 2001 (Table 1), independent predictors of not receiving an ICD after surviving an hospitalization for CA included older age (odds ratio [OR] 0.93 for every 10-year increase in age, \( p < 0.001 \)), black race (OR 0.19, \( p < 0.001 \)), and being admitted to a small hospital (OR 2.24 for every 100-bed increase in hospital size, \( p < 0.001 \)). The presence of renal or respiratory failure was also a risk factor for not receiving an ICD after surviving CA.

**DISCUSSION**

The results of this study suggest that ICD therapy is being underutilized for secondary prevention of CA, a finding consistent with previously published data (10,14). Still, in 2001, the majority of patients admitted with malignant ventricular arrhythmias did not receive ICD therapy before discharge.

There are multiple potential explanations for ICD underutilization in this high-risk population. First, implant rates are highly associated with economic factors (15), including health care budgets, hospital size and resources, the availability of electrophysiologists, and possibly also with insurance coverage. Our analysis suggests that there is a direct relationship between hospital size and ICD implantation rates, which may partially reflect the availability of procedures in the smaller hospitals. There may be a general reluctance within the medical community to implant defibrillators in survivors of CA who have significant co-morbidities and limited life-expectancy. Finally, health care providers’ perception of CA as a painless way of dying may provide a barrier to appropriate ICD utilization (16).

This study also demonstrates the powerful influence of demographic factors on ICD implantation rates. We show that among CA survivors, women are less likely than men to receive an ICD, a finding consistent with previous studies (17). It is promising, however, to see that this gender gap is closing in more recent years; in particular, in the year 2001, a higher percentage of women than men received an ICD after surviving CA.

Increasing age was also associated with lower defibrillator implantation rates. This apparent inequity can be partially explained by the limited life-expectancy, higher incidence of co-morbid conditions, and increased reluctance to undergo invasive procedures in the elderly. This trend is concerning, however, for several reasons. First, the incidence of out-of-hospital cardiac arrest is highest in elderly patients (18). In addition, economic analysis of a CA trial (19) suggested that

---

**Table 1.** Binary Logistic Regression Analysis Showing the Independent Predictors of Receiving a Defibrillator Among Survivors of Sudden Cardiac Death in the United States for the Years 2000 and 2001

<table>
<thead>
<tr>
<th>Predictor</th>
<th>( p ) Value</th>
<th>OR</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per 10-yr increase)</td>
<td>&lt;0.001</td>
<td>0.93</td>
<td>0.90</td>
<td>0.96</td>
</tr>
<tr>
<td>Gender (women vs. men)</td>
<td>NS</td>
<td>1.07</td>
<td>0.98</td>
<td>1.16</td>
</tr>
<tr>
<td>Race (black vs. white)</td>
<td>&lt;0.001</td>
<td>0.19</td>
<td>0.13</td>
<td>0.29</td>
</tr>
<tr>
<td>Hospital size (per 100+ beds)</td>
<td>&lt;0.001</td>
<td>2.24</td>
<td>2.15</td>
<td>2.33</td>
</tr>
<tr>
<td>Renal failure</td>
<td>&lt;0.001</td>
<td>0.25</td>
<td>0.14</td>
<td>0.46</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>&lt;0.001</td>
<td>0.73</td>
<td>0.67</td>
<td>0.79</td>
</tr>
<tr>
<td>Cardiovascular failure</td>
<td>NS</td>
<td>0.86</td>
<td>0.61</td>
<td>1.19</td>
</tr>
</tbody>
</table>

CI = confidence interval; NS = not significant; OR = odds ratio.
placing an ICD in patients age 70 years or older is associated with a lower cost for the ICD per year of life saved, as compared with a population younger than 70 years.

During the study period, blacks were over three times less likely than whites to receive ICD therapy for CA, even after accounting for other co-morbid conditions. One contributing factor may be a difference in rates of consent between blacks and whites, which has been shown elsewhere (20,21).

Patient preferences alone cannot fully account for the dramatic disparities seen in our study. In the Cardiac Access Longitudinal Study, blacks were less likely than whites to see a cardiologist regularly, follow up with a physician who is board-certified, or be admitted to a facility with a catheterization laboratory (22). Our findings are consistent with recent data showing racial disparity in percutaneous coronary intervention and ICD utilization (22,23), which clearly deserve continuing investigation.

Our retrospective, observational study has several important limitations. The NHDS data base lacks detailed clinical information. The validity of the data depends on the appropriate use of ICD-9-CM codes at the time of hospital discharge. The definition of CA in our study relies totally on the ICD-9-CM code entered into the NHDS data base. There are no means to confirm the accuracy of the diagnosis of VF (e.g., through review of electrocardiographic tracings or other parts of the medical record). Also, co-morbid illnesses, for example, have been shown to be underreported in hospital discharge data (24). In our study, underrepresentation of acute MI as a secondary diagnosis could explain some of the apparent low ICD rates in survivors of CA. Several important factors, such as patient refusal of recommended therapy, cannot be measured. It is impossible to say with certainty if patients received defibrillator therapy in the weeks or months after discharge.

This study suggests marked underutilization of ICD therapy in survivors of CA in the U.S. There are alarming disparities along race lines in the treatment of those at highest risk of CA. At a time when indications for ICD therapy are expanding, efforts should be focused toward identifying the causes of these disparities.

Reprint requests and correspondence: Dr. Samir Saba, Division of Cardiac Electrophysiology, University of Pittsburgh Medical Center, 200 Lothrop Street, B535 PUH, Pittsburgh, Pennsylvania 15213. E-mail: saba@msx.upmc.edu.

REFERENCES


