ORIGINAL ARTICLE

Management of patients with implantable cardioverter defibrillators at emergency departments

Chung-Pin Liu, Yi-Lwun Ho, Yen-Hung Lin, Yen-Bin Liu, Wei-Tien Chang, Chien-Hua Huang, Wen-Jone Chen

Emerg Med J 2007;24:106–109. doi: 10.1136/emj.2006.037788

See end of article for authors' affiliations

Correspondence to: Wen-Jone Chen, Department of Emergency Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan, No 7 Chung-Shan South Road, Taipei 100, Taiwan; jone@ha.mc.ntu.edu.tw

Accepted 22 November 2006

Background: With rapid improvements in technology and accumulation of clinical evidence, the implantable cardioverter defibrillator (ICD) has become a standard treatment for either primary or secondary prevention of sudden cardiac death. However, no analysis based on the perspective of emergency department has been reported, and managing patients with ICD remains a challenge to the emergency department doctors.

Methods: This study reviewed the emergency department visits of patients who received ICD implantation in a single university hospital from 1995 to 2004. The baseline demographic and laboratory data were compared between groups with the non-parametric method of the Mann–Whitney U test for continuous data and the χ^2 test for categorical data; $p < 0.05$ was considered significant.

Results: 81 patients (56 men and 25 women) were included in this study. 43% of patients had at least one emergency department visit during the follow-up period, and a total of 86 emergency department visits were recorded. The most frequent aetiology of emergency department visits was ICD discharge (37 episodes; 43.1%) and the most frequent presenting symptom was electric shock sensation (25 episodes; 29.1%). Only 11 (12.8%) emergency department visits were because of non-cardiac aetiologies. Patients with emergency department visits had significant lower left ventricular ejection fraction (mean (SD) 41.5 (19.8) v 55.2 (18.4) ejection fraction units; $p = 0.005$) and more use of warfarin (8.6% v 0%; $p < 0.05$). Although most emergency department visits were device or arrhythmia related, the acute coronary syndrome and congestive heart failure still accounted for 27.9% of hospital returns in combination.

Conclusions: Defibrillator discharge, acute coronary syndrome and heart failure constitute most aetiologies of emergency department visits of patients with ICD. The risk factors include lower left ventricular ejection fraction and use of warfarin.

With rapid improvements in technology and accumulation of clinical evidence, the implantable cardioverter defibrillator (ICD) has become the standard treatment for primary or secondary prevention of sudden cardiac death.^{1–3} However, given the common feature of multiple comorbidities or advanced heart disease in patients with ICD, there is a high incidence of hospital readmission of these patients after implantation, either in clinical trials or large-scale registry.^{4–5} Although the complications and late outcomes have been well defined for this patient group, there is a paucity of data describing the clinical features of patients with ICD at emergency departments. In real life, managing a patient with ICD remains a challenge to the emergency physicians. The aim of this study was to show the presentations and clinical characteristics of patients with ICD at emergency departments and to describe the treatment algorithm at the emergency department of a university hospital.

PATIENTS AND METHODS

This study retrospectively enrolled all consecutive patients who received ICD implantation at the National Taiwan University Hospital, an academic teaching hospital in Taipei, Taiwan. The indications of ICD implantation include cardiac arrest or syncope due to ventricular tachycardia/ventricular fibrillation, sustained ventricular tachycardia in structural heart disease, Brugada syndrome and unexplained syncope with inducible ventricular tachycardia/ventricular fibrillation at the electrophysiological laboratory.⁶ The clinical and hospital charts were reviewed, and the baseline characteristics of the patients were recorded. The clinical follow-up was continued at the outpatient clinic or by telephone contact after implantation. All the

emergency department visits were identified, including those at the National Taiwan University Hospital or other institutions. The presenting symptoms, emergency department diagnosis, management and results of ICD interrogation were recorded.

Statistical analysis

Data are presented as mean (standard deviation). The statistical analysis was performed with the SPSS software. The baseline demographic and laboratory data were compared between groups with the non-parametric method of the Mann–Whitney U test for continuous data and the χ^2 test for categorical data. $p < 0.05$ was considered significant.

RESULTS

From 1995 to 2004, a total of 81 patients (56 men and 25 women) who received ICD implantation at our hospital were identified. The patients were aged 7–86 years, with a mean age of 57.5 years. Of them, 29 (35.8%) patients had coronary artery disease and 14 (17.2%) patients had previous myocardial infarction. The patients were followed up for an average of 45 months. Of these patients, 43% had at least one emergency department visit. The baseline characteristics were compared between patients with emergency department visits and those without (table 1). Patients with emergency department visits had significant lower left ventricular ejection fraction (LVEF; 41.5 (19.8) v 55.2 (18.4) ejection fraction units; $p = 0.005$) and more use of warfarin (8.6% v 0%; $p < 0.05$). There was no significant difference in emergency department visits in

Abbreviations: ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction

Table 1 Baseline characteristics of patients with or without emergency department visits

	With ED visit (n = 35)	Without ED visit (n = 46)	p Value
Age (years)	58.5 (16.7)	56.7 (18.7)	0.797
Men/women	25/10	31/15	0.697
Creatinine (mg/dl)	1.2 (0.5)	1.3 (0.9)	0.638
CAD (%)	31.4	39.1	0.474
Old MI (%)	20	15.2	0.573
LVEF (%)	41.5 (19.8)	55.2 (18.4)	0.005
Aspirin use (%)	40	43.5	0.753
Warfarin use (%)	8.6	0	0.043
NYHA Fc	1.5 (0.6)	1.4 (0.6)	0.156
Antiarrhythmics (n)*	1.2 (0.7)	1.0 (0.6)	0.139
Platelet count (10 ³ /μl)	196 (57)	211 (64)	0.243
VT v VF	7/28	14/32	0.288
Follow-up period (days)	1167 (1261)	1601 (1193)	0.121

CAD, coronary artery disease; ED, emergency department; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NYHA Fc, New York Heart Association functional class; VF, ventricular fibrillation; VT, ventricular tachycardia.

Values are mean (SD) unless otherwise specified.

*Types of antiarrhythmic agents used.

patients with coronary artery disease or previous myocardial infarction. The distribution of ventricular tachycardia and ventricular fibrillation was not significantly different between patient groups with or without emergency department visits.

Eighty six emergency department visits were recorded during the follow-up period, and the calculated emergency department visit rate was 0.29/patient-year of follow-up. Table 2 lists the symptoms of patients on arrival at the emergency department. The most frequent presenting symptom was electric shock sensation (n = 25, 29.1%). Only 9 (10.5%) emergency department visits were because of non-cardiac or device-related symptoms. Figure 1 presents the patient management algorithm in our hospital. The most frequent aetiology of emergency department visits of these patients was defibrillator discharge, which accounted for 43.1% of total emergency department visits. Of electric shocks, 89% were appropriate, which means that a ventricular tachycardia or ventricular fibrillation event was detected and treated successfully with defibrillation. The aetiologies of inappropriate electric shocks include mis-sensing supraventricular tachycardia and lead noise. Acute coronary syndrome and congestive heart failure accounted for 27.9% of total emergency department visits, and the treatment depended on the individual patient's conditions. During our follow-up period, 8 (9.9%) patients died, and the overall follow-up rate was 91.4%.

DISCUSSION

Emergency department physicians are facing an increasing number of patients with ICD with multiple comorbidities. Our results show a high probability of emergency department visits in patients after ICD implantation. Up to 43.2% of patients in

this study had at least one emergency department visit during the follow-up period and the emergency department visit rate was 0.29/patient-year during the follow-up. This corresponds to the results from previous series. Fahy *et al*⁷ reported a cardiac-related hospital readmission rate as high as 0.72/patient-year of follow-up in a single medical institution in the US, and Korte *et al*⁸ reported a readmission rate of 0.46/patient-year in Germany. In this study, we excluded the hospitalisations that were not referred to our emergency department. Thus, our data may be closer to the real loading of emergency department physicians.

We found lower LVEF and increased use of warfarin in patients with emergency department visits (table 1). There were still some controversies for the causes of rehospitalisation of patients with ICD. The heart failure symptoms with New York Heart Association functional classes III and IV but not LVEF were important predictors of a shorter time to the first cardiac-related readmission.⁷ However, Korte *et al*⁸ could not find any independent predictor in their series. Different distribution of patients may explain this phenomenon. In our hospital, we performed ICD implantation in much fewer patients with congestive heart failure compared with patients with idiopathic ventricular tachycardia/ventricular fibrillation.⁹ This is because we are in a region endemic for Brugada syndrome,^{10,11} and we have a prevalence of ischaemic heart disease lower than Western countries. Only 35.8% of patients in our study population had coronary artery disease, and only 17% had old myocardial infarction; much lower in comparison to the series in Western countries.^{12,13} Thus, the distribution of aetiologies for hospital return might differ from other reports. Increased warfarin use also predicts emergency department visits in patients with ICD, reflecting the remarkable proportion (7%) of wound haematoma or generator dislocation in our study population.

In our series, hardware-related problems caused 10.5% of all emergency department visits, including 3.5% of infection and 7% of generator-related problems. This is still a high rate of problems due to devices; however, our data were similar to previous reports of large-scale studies.^{8,14,15} In our small series, no specific technique or hardware used could be analysed for explanation. Future advances in reducing generator size, antiseptic lead and implantation technique may be helpful.

In patients who experienced appropriate shocks during ventricular arrhythmia, the defibrillator can be reprogrammed to improve its effectiveness and the antiarrhythmic drugs can be adjusted to prevent the recurrence of ventricular tachycardia and ventricular fibrillation.¹⁶ In patients with inappropriate shocks, the aetiologies include supraventricular tachyarrhythmia

Table 2 Symptoms on presentation at emergency department visits

Symptom	n (%)
Electric shock	25 (29.1)
Chest pain	15 (17.4)
Short of breath	13 (15.1)
Palpitation	12 (14.0)
Non-cardiac	9 (10.5)
Wound discomfort	5 (5.8)
Dizziness	4 (4.7)
Fever	3 (3.5)
Total	86 (100)

Figure 1 Aetiology and treatment algorithm of emergency department visits for patients with implantable cardioverter defibrillator (ICD) implant. ACS, acute coronary syndrome; CHF, congestive heart failure; CXR, chest x ray; ED, emergency department; SVT, saphenous vein thrombophlebitis; VF, ventricular fibrillation; VT, ventricular tachycardia.

mia, oversensing T waves, double counting of pacing artefacts and oversensing lead insulations. Our data showed that 4.7% of emergency department visits were related to inappropriate shocks. Reprogramming of the defibrillator, treatment with drugs and lead replacement may help individual patients.¹⁷

Several limitations were noted in this study, including a relatively small number of patients and a single-centre experience. Lack of a control group confounds the readmission reasons for our patient groups. The small number of patients with low LVEF receiving ICD in our study population limits its generalisability. However, in contrast with previously raised algorithms,¹⁸ our series provides unique information from the point of view of the emergency department.

In conclusion, patients with ICD implantation had a high probability of emergency department visits. Defibrillator discharge, acute coronary syndrome and heart failure constituted most of the aetiologies. Conversance with these issues would help the emergency department physicians to provide effective and timely care for this patient group.

Authors' affiliations

Chung-Pin Liu, Department of Internal Medicine (Division of Cardiology), Yuan's General Hospital; Kaohsiung Medical University College of Medicine, Kaohsiung, Taiwan

Yi-Lwun Ho, Yen-Hung Lin, Yen-Bin Liu, Chien-Hua Huang, Wen-Jone Chen, Department of Internal Medicine, Division of Cardiology, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan

Wei-Tien Chang, Chien-Hua Huang, Department of Emergency Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan

Competing interests: None declared.

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