Current Trends in Implantable Cardioverter-Defibrillator Therapy in Children
— Results From the JCDTR Database —

Hiroko Asakai, MD; Akihiko Shimizu, MD, PhD; Takeshi Mitsuhashi, MD, PhD; Takeshi Ueyama, MD, PhD; Hisashi Yokoshiki, MD, PhD; Nobuhiro Nishii, MD, PhD; Yukio Sekiguchi, MD, PhD; Hideo Okamura, MD, PhD; Norishige Morita, MD, PhD; Takeshi Nitta, MD, PhD; Kenzo Hirao, MD, PhD; Members of the Implantable Cardioverter-Defibrillator (ICD) Committee of the Japanese Heart Rhythm Society

Background: Implantable cardioverter defibrillators (ICDs) are being used with increasing frequency in children. Our aim was to examine the current trend of pediatric ICD implantation in Japan.

Methods and Results: Data was extracted from the Japanese Cardiac Device Treatment Registry (JCDTR), a nation-wide registry started in 2006. All patients aged less than 18 years who had an ICD implantation registered between 2006 and 2016 were included in the analysis. A total of 201 patients were included, with a median age of 16 years (range 1–18). The underlying cardiac diagnosis was primary electrical disease (67%), cardiomyopathy (26%) and congenital heart disease (4%), with idiopathic ventricular fibrillation (29%) and long QT syndrome (21%) being the 2 most common diagnoses. Implantation indication was primary prevention in only 30 patients (15%). There were 27 patients (13%) aged ≤12 years, with a larger proportion of patients with cardiomyopathy (33%). The indication in younger children was secondary prevention in all cases. Younger children may be under-represented in our study given the nature of the database as it is a predominantly adult cardiology database.

Conclusions: In the past decade, ICD implantation has been performed in approximately 20 children per year in Japan, mostly for secondary prevention. There was no increase in the trend nor a change in age distribution.

Key Words: Implantable cardioverter-defibrillators; Japan; National registry; Pediatrics

Implantable cardioverter-defibrillators (ICDs) are a useful tool for improving the prognosis and/or sudden cardiac death event rate in patients with heart failure and/or fatal ventricular arrhythmias.1,2 The first clinical guidelines for ICDs in Japan were published by the Japanese Circulation Society (JCS) in 2001, with the most recent revision reported in 2011.3 The Japan Cardiac Device Therapy Registry (JCDTR) was established in 2006 by the Japanese Heart Rhythm Society (JHRS) for a survey of actual conditions in patients undergoing cardiac device implantation. Data from the JCDTR registry demonstrates differences in device implantation rates compared with previously published international studies.4–6 These differences in device utilization may be explained by factors such as acceptance of published guidelines, clinical presentation of patients, accessibility to electrophysiologists and institutions specializing in device management, and acceptance by policy-makers, cost-effectiveness, and financial constraints.7

The aim of our study was to assess the trends in ICD utilization in the Japanese pediatric population based on the JCDTR database.

Methods

Study Population
The JCDTR questionnaires consisted of three section,
including implantation information, patient characteristics, and pharmacological treatment at the time of enrollment. The details are described in a previous report. As of January 2006, a total of 367 institutions in Japan had registered data for 27,074 patients. Of note, the participating institutions are adult-only or adult and pediatric combined centers, with no participation of children’s hospitals. In this study, data for all pediatric patients under the age of 18 years who had an ICD were extracted from this database. Underlying heart disease, indication of device implantation, and the difference in patient characteristics of younger children (age ≤12 years) vs. older children were investigated.

Patient diagnoses were determined according to the answers on the JCDTR questionnaire. The underlying cardiac disease was divided into 4 main categories: primary electrical, cardiomyopathy, congenital heart disease and other cardiac disease. Primary electrical disease was further categorized to long QT syndrome (LQTS), arrhythmogenic right ventricular cardiomyopathy (ARVC), Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia (CPVT), idiopathic ventricular fibrillation (IVF) and non-specified arrhythmia disease. Cardiomyopathy was categorized to dilated cardiomyopathy (DCM), hypertrophic cardiomyopathy (HCM) and other forms of cardiomyopathy including restricted cardiomyopathy, left ventricular non-compaction and secondary cardiomyopathy. The trend in ICD implantation over the 10-year study period was examined. Furthermore, details of epicardial implantations, and implantations in smaller children were investigated.

Statistical Analysis
Categorical data are expressed as mean±SD or median and range as appropriate. The comparison between the 2 age groups was performed using Student’s t-test or chi-square test. Statistical analysis was performed using SPSS (IBM, ver. 23, Armonk, NY, USA).

Ethical Concerns
The JCDTR database was approved by the ethics committee at each participating institution.

Results
Trends in ICD Implantation in Children
During the study period, out of the 27,074 data registered there were 16,927 (62%) ICD implantations. A total of 201 pediatric implantations were identified, which was 1.1% of the entire ICD cohort. Of the 367 participating institutions, 111 (30%) contributed at least 1 pediatric patient to the database, with the majority of institutions reporting only 1 pediatric implantation during the 10-year study period. There were only 4 institutions that had performed more than 5 pediatric implants (Figure 1). The patient distribution by era is shown in Figure 2. The number of implants over the years has not increased with an average implant of 18±5 implants per year. Half of the patients had a single-chamber device. The median age at implant was 16 years old (range 1–18), with very few implants in children under the age of 12 (13%) (Figure 3).

Patients’ Characteristics
The underlying cardiac diagnoses are shown in Table 1. More than half of the patients had primary electrical disease, with a high incidence of IVF (29%). Implant indication was primary prevention in 30/201 (15%) and secondary prevention in 171/201 (85%). There was no increase in the prevalence of primary prevention ICD implantation over the years when comparing the recent era (2011–2016) with the first half of the study period (2006–
Current Trend of Pediatric Device Implantation in Japan

According to the JADIA database, the total number of device implantation in children aged <16 years between 2000 and 2012 was 280: 200 ICD, 67 CRTP, and 13 CRTD.

Our data included 201 patients, of whom 126 were <16 years old. Based on the numbers from the JADIA database, we can speculate that approximately three-quarters of ICD implantations in children <16 years old were included in our database. The higher inclusion rate compared with the JPCCS survey is likely due to mainly 2 factors, the first being the strict governmental criteria for accreditation for ICD implantation, which has resulted in few or no children’s hospitals being accredited to perform ICD implantations, and second, older patients are underrepresented in the JPCCS survey as the majority of these patients are likely to receive a transvenous device performed at an adult cardiology service. In our current database, there was no trend

2010) (Figure 4). The underlying cardiac diseases in patients with primary prevention ICDs were primary electrical disease in 17 (57%), cardiomyopathy in 11 (37%) and congenital heart disease in 2 (7%). The reasons for primary prevention ICD were syncope in 14 (47%), non-sustained VT in 6 (20%), decreased ventricular function in 1 (3%) and not specified in 9 (30%).

Epicardial Implantation

There were only 6 patients who had an epicardial implantation (Table 2). Most patients were younger than 8 years or had complex congenital heart disease (5/6). One 17-year-old with a structurally normal heart and IVF had an epicardial implantation; however, the indication was unclear. All 6 patients had a single-coil transvenous defibrillation lead implanted. There were no implant-related complications.

Discussion

This is the largest study to date investigating the use of ICD therapy in the pediatric population in Japan. The only other pediatric data available are in a report of a multicenter questionnaire performed by the Japanese Pediatric Cardiology and Cardiac Surgery (JPCCS) Society. Their data included a total of 152 children aged <16 years who had device implantation (either ICD or CRT) before 2012 in 15 children’s hospitals and 74 general hospitals. There were 64 ICDs, 81 CRTs, and 7 CRTD implantations. Of note, patients who had cardiac resynchronization using a dual-chamber pacemaker were also included. There is also an industry database organized by the Japan Arrhythmia Device Industry Association (JADIA), which registers all cases of ICD and CRT implantation in Japan; however, there is limited data available regarding patient details including age at implantation and underlying heart disease.

According to the JADIA database, the total number of device implantation in children aged <16 years between 2000 and 2012 was 280: 200 ICD, 67 CRTP, and 13 CRTD. Our data included 201 patients, of whom 126 were <16 years old. Based on the numbers from the JADIA database, we can speculate that approximately three-quarters of ICD implantations in children <16 years old were included in our database. The higher inclusion rate compared with the JPCCS survey is likely due to mainly 2 factors, the first being the strict governmental criteria for accreditation for ICD implantation, which has resulted in few or no children’s hospitals being accredited to perform ICD implantations, and second, older patients are underrepresented in the JPCCS survey as the majority of these patients are likely to receive a transvenous device performed at an adult cardiology service. In our current database, there was no trend
towards an increase in device implantations in children in the past 10 years. The JADA database also demonstrated that the number of ICD implantation has remained static, with approximately 20–25 implants per year between the period of 2006 and 2012.

Implant Characteristics

The majority of the patients in our cohort were older than 15 years, and most had a transvenous dual-chamber ICD. Only 15% of the implants were for primary prevention, with no significant increase in primary prevention ICDs during the study period. This is a significantly smaller proportion of primary prevention ICD compared with previously reported data of close to 50% 8, 9. A multicenter study including 443 pediatric and congenital heart disease patients in 4 US pediatric centers, reported a significant increase in primary prevention ICD from less than 50% in the 90s to close to 60% in the early 2000s. 9, 10 This may be in part due to the lack of pediatric electrophysiologists as well as pediatric centers accredited to perform ICD implantations, resulting in the therapy being less readily available in this patient population.

Epicardial Implantation

There were only 6 patients who had an epicardial implantation, most of whom were under the age of 8 years. All 4 patients under the age of 8 years underwent an epicardial implantation. Similarly, results from the JPPCS survey show that almost all patients (80/83 [96.3%]) under the age of 8 years had an epicardial implantation (this includes patients who had CRT devices). The young age group might be under-represented in our cohort because of the higher rate of epicardial implantations, which are most likely performed by pediatric cardiac surgeons, hence with little involvement of the adult cardiology team. The overall cutoff for a transvenous system appeared to be over the age of 10 years old, in both the JCDTR database and JPPCS. Unfortunately, data regarding body weight and body height at the time of implantation are lacking so we were unable to perform any further analysis.

Study Limitations

The majority of the participating physicians and institutions are adult cardiologists, with limited participation of pediatric cardiologists and children’s hospitals. Data regarding weight and height at time of implantation were lacking, and there was also a lack of follow-up details, including complications and ICD discharges at follow-up.

Conclusions

ICD therapy remains underutilized in the pediatric population in Japan, with less than 30 implants per year. In particular, there are very few primary prevention ICDs, with no trend in increase over the past 10 years. A further comprehensive registry including follow-up data in collaboration with the pediatric cardiology community is required.

References


Table 2. Details of Japanese Pediatric Patients With Epicardial ICD Implantation

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Year</th>
<th>Diagnosis</th>
<th>Device</th>
<th>Lead</th>
<th>DFT</th>
<th>EPS</th>
<th>Medication</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
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<td>2015</td>
<td>CM</td>
<td>S</td>
<td>S</td>
<td>15</td>
<td>VT</td>
<td>1B, BB, Amio, CCB</td>
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<tr>
<td>2</td>
<td>2</td>
<td>F</td>
<td>2012</td>
<td>BrS</td>
<td>S</td>
<td>S</td>
<td>NP</td>
<td>–</td>
<td>Bepridil</td>
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<tr>
<td>3</td>
<td>8</td>
<td>F</td>
<td>2012</td>
<td>LVNC</td>
<td>D</td>
<td>S</td>
<td>25</td>
<td>–</td>
<td>BB</td>
</tr>
<tr>
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<td>8</td>
<td>M</td>
<td>2015</td>
<td>CPVT</td>
<td>S</td>
<td>S</td>
<td>NP</td>
<td>VF</td>
<td>BB, 1B, 1C</td>
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<tr>
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<td>F</td>
<td>2012</td>
<td>s/p TCPC</td>
<td>D</td>
<td>S</td>
<td>30</td>
<td>VT</td>
<td>BB, Sotalol</td>
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<tr>
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<td>17</td>
<td>M</td>
<td>2013</td>
<td>IVF</td>
<td>S</td>
<td>S</td>
<td>10</td>
<td>NA</td>
<td>BB</td>
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Amio, amiodarone; BB, β-blocker; CCB, calcium-channel blocker; Device D, dual-chamber device; Device S, single-chamber device; DFT, defibrillation threshold; EPS, electrophysiology study; Fontan, status post Fontan operation; ICD, implantable cardioverter-defibrillator; Lead S, single coil; LVNC, left ventricular non-compaction; NA, no inducible arrhythmia; NP, not performed. Other abbreviations as in Table 1.

Acknowledgments

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