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Life expectancy after implantation of a first cardiac permanent pacemaker (1995–2008): A population-based study☆,☆☆

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ABSTRACT

Introduction: Research suggests that survival among the recipients of a cardiac permanent pacemaker (PPM) matches the age- and sex-matched general population in the absence of cardiovascular disease. We used linked administrative data to examine life expectancy-based outcomes for adults requiring a cardiac PPM.

Methods: Population-level hospital admissions data were used to identify all recipients of an initial PPM during 1995–2008. Expected years of additional life remaining at the time of implantation were calculated for each patient from population life tables. Observed years were calculated using linked mortality data to end 2011. Cox regression was used to determine demographic and clinical predictors of survival.

Results: In 8757 patients age-adjusted risk of death to 5 years was associated with male sex, higher Charlson Comorbidity Index score (excluding cardiac disease), a history of heart failure, cardiomyopathy or atrial fibrillation and emergency admission. Coronary revascularisation surgery reduced long-term risk. The observed/expected ratio of additional years of life was 0.80 for men and 0.84 for women overall, varying from 0.92 for women without significant comorbidity to 0.40 for patients with the highest Charlson score and cardiomyopathy. The oldest patients (80–99 years) did relatively well, probably reflecting patient selection. Heart disease was the most frequent cause of death.

Conclusions: Life expectancy among PPM recipients without significant comorbidity approached that of the general population. Greater non-cardiac comorbidity, heart failure, atrial fibrillation and, in particular, cardiomyopathy, contributed most to the loss of expected years of life in all age groups. The oldest patients and women did relatively well.

1. Background

While long-term survival for adult recipients of a cardiac permanent pacemaker (PPM) shows the expected age-related decline [1] there is little information on what this means in terms of life expectancy (LE) compared to the general population. A single centre study from England of 803 patients with PPMs implanted in the early 1990s, with follow-up to seven years, reported overall survival fell well below that of the age- and sex-matched population [2]. The cohort included patients with a range of cardiac and non-cardiac comorbidities. More recently, a nation-wide follow-up of 1517 patients from 2003–2007 in the Netherlands found survival to a minimum of 3.3 years significantly worse for the more than 50% of patients with concomitant cardiovascular disease (CVD) than the age- and sex-matched general population. However, survival for recipients without CVD matched that of the general population. This was also the case for the oldest old (octogenarians and nonagenarians) [3,4]. Similar findings for elderly patients without symptomatic heart disease were reported in earlier decades from a small study from Olmsted County, Minnesota [5], and survival for age–sex- and comorbidity-matched Taiwanese nonagenarians implanted with PPMs from 2001–2012 was no worse than for controls [6]. Commonly identified factors associated with increased risk for death after PPM implantation include older age, CVD, heart failure (HF) and cardiomyopathy [1–6].

'Years of potential life lost' up to age 65 or 75 years is a frequently used population health measure as a reference against which to estimate premature deaths [7] but is not useful for studies of PPM outcomes as the average age of patients requiring a first PPM exceeds 75 years in developed countries [3,8]. We selected 'expected (remaining) years of life lost' (EYLL), based on the complete expectation of life, to measure

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the gap between estimated LE and actual age at death [9], providing a more clinically meaningful measure of outcomes for recipients of a PPM in ageing populations.

To determine whether life expectancy after initial implantation of a PPM meets that expected for the patients' age and era we calculated and compared the observed and expected years of life up to 31 December 2011 for groups of PPM recipients who received their first PPM during 1995–2008 in the state of Western Australia (WA).

2. Methods

Thirty years of linked hospital and mortality data from WA were used in a retrospective cohort study to examine survival and life expectancy outcomes among a population of patients who had a first PPM implanted between 1995 and 2008.

2.1. Data sources and patient selection

The data sources for the study cohort have been described previously [10]. Briefly, the study used de-identified, linked data prepared by the Data Linkage Branch of the Health Department of WA. The linked file available for this study included all admissions and deaths for all patients hospitalised in WA for CVD from 1980 to 2011. This file was used to identify PPM admissions, defined as an admission with a World Health Organisation's International Classification of Diseases (ICD-9CM and ICD-10) diagnosis or procedure for insertion or management of a cardiac pacing device (available from author) for the years 1980–2009. Admissions with a procedure code for an implantable cardioverter defibrillator alone, without an additional code for pacing, were excluded. Using 15-year look back to identify incident cases, a cohort of patients who had their first PPM admission during 1995 to 2008 was identified. As the indications for pacing differ between children and adults, we excluded patients younger than 30 years and those with congenital heart disease ($n = 97$), as well as five people aged ≥100 years, for whom LE data are not available/reliable.

2.2. Study variables

Coded cause of death was available to the end of 2010.

Cardiac conditions were identified from the 'principal' and 19 additional 'diagnosis' fields. The major indications for PPM insertion were categorised according to those used in the world surveys of pacing [11], and in a hierarchical fashion (major indication in principal diagnosis, secondary diagnosis etc.).

Pacemaker type (single, dual, triple chamber or 'not otherwise specified') was identified from the 11 'procedure' fields.

The Charlson Comorbidity Index, a widely-used tool used to predict mortality by weighting a range of comorbid conditions, such as heart disease or cancer (a total of 17 conditions), was calculated. We used the method of Quan and others [12] for administrative data, based on the ICD-9CM and ICD-10 codes recorded in the index admission and all admissions in the previous five years. Acute myocardial infarction (AMI) and HF were excluded as comorbidities in the Charlson score as they were frequently the primary disorder and were considered as separate variables as were diagnoses of atrial fibrillation/flutter (AF), cardiomyopathy or cardiac valve disease recorded in the index admission. The final Charlson score was categorised as zero (no comorbid non-cardiac conditions recorded), a score of 1–2, 3–4, or of 5 or more.

The 'complete expectation of life at exact age' was calculated for each patient using the life-tables for WA [13–15] and based on the patient's age in the year of PPM implantation. For example, a female who had a first pacemaker implanted in 2001 at the age of 72 years could expect to live another 15.5 years, to year 2016.

The total 'expected' years of remaining life for the whole cohort was calculated from the date of index PPM hospital discharge to the date of LE or the study end date (31st December, 2011), whichever was first, and total 'observed' years of life to the date of death or the end date (to a maximum of 16 years), whichever came first.

The EYLL up to the study end date was calculated by subtracting the total 'observed' years of life from total 'expected' years of life.

Coded 'underlying cause of death' was available for deaths up to end of 2010 and was grouped into system-related deaths using the tenth revision, Australian Modification, of ICD-10 e.g. Chapter 9: Diseases of the Circulatory System (I00–I99). Specific conditions such as ischaemic heart disease (I20–I25) and Alzheimer's disease (G30) were identified for comparison with national age-specific causes of death [16].

2.3. Study outcomes

Long-term survival, survival compared to the general population (the ratio of observed to expected years of additional life) and the EYLL for those discharged from hospital alive after initial implantation of a PPM.

2.4. Ethics

The study was approved by the Human Research Ethics Committees at the University of Western Australia and Health Department of Western Australia.

2.5. Statistical analysis

The demographic and clinical characteristics of the cohort are described using the mean and standard deviation (SD) and percentages. The cohort was grouped by age at PPM implantation into 30–59, 60–70 and 80–99 years. Age at death was grouped as 30–44, 45–54, 55–64, 65–74, 75–84 and ≥85 years for comparison with Australian national 'cause of death' statistics.

Groups were defined by sex, age-group at implantation, era (i.e. calendar period), cardiac history, diagnosis, Charlson score, and emergency or elective hospital admission. Differences between groups were tested using the chi-squared test for categorical factors and the Student's 't-test' or one-way ANOVA for quantitative variables. Observed and expected remaining survivals were compared across groups using two statistics: the ratio of the total observed to total expected years for each group, and the mean EYLL for each group.

Two time-to-death (from all causes) outcomes were analysed using Cox regression models. The first (one year mortality) restricted follow-up to one year and the second (5-year mortality) used all available follow-up up to 5 years for each patient, censored at 31st December, 2011. Each variable was initially tested separately for associations with one-year and 5-year all-cause mortality in a Cox model that adjusted for age group as a covariate (age-adjusted univariate associations). Variables significantly associated with each mortality outcome, after adjustment for age, were then included in a multivariable Cox model to identify the independent predictors of death. The assumption of proportionality of hazards in the Cox model was tested using an interaction between follow-up time and the Variable, and in all cases the assumption was met. A 'p' value of <0.05 was considered statistically significant.

Analyses were carried out in IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. SPSS Version 21.

3. Results

3.1. Patient characteristics

There were 8847 incident PPM cases aged 30–99 years during the period 1995–2008, with 90 deaths in hospital. The characteristics of the cohort of 8757 patients discharged from hospital are shown in Table 1 by study period; 59% were male, 39% were aged 80–99 years, and about half were emergency admissions.