# Trends in Cardiac Tamponade Among Recipients of Permanent Pacemakers in the United States From 2008 to 2012

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## ABSTRACT

**OBJECTIVES** The aim of this study was to describe the trends and predictors of cardiac tamponade among permanent pacemaker (PPM) recipients in the United States between 2008 and 2012.

**BACKGROUND** Limited data exist regarding the burden, trend, and predictors of tamponade in patients following PPM implantation.

**METHODS** The National (Nationwide) Inpatient Sample database was used to identify PPM implantations between 2008 and 2012.

**RESULTS** Among 922,549 patients who received PPM devices between 2008 and 2012, cardiac tamponade occurred in 2,595 patients (0.28%). Overall, in-hospital cardiac tamponade rates increased by 35% among recipients of PPMs. The incidence rate steadily increased from 0.26% in 2008 to 0.35% in 2012 (p < 0.0001). Although the mean age (p = 0.28) and sex distribution (p = 0.25) did not change over the years, the rate of in-hospital mortality increased among patients who developed tamponade from 2008 to 2012 (p = 0.014). After multivariate adjustment for patient and hospital characteristics, female sex (odds ratio [OR]: 1.23; 95% confidence interval [CI]: 1.04 to 1.54; p = 0.011), dual-chamber pacemakers (OR: 1.68; 95% CI: 1.17 to 2.41; p < 0.004), and chronic liver disease (OR: 3.18; 95% CI: 1.92 to 5.64; p < 0.001) were found to be independently associated with a greater odds of cardiac tamponade. Conversely, hypertension (OR: 0.71; 95% CI: 0.45 to 0.94; p = 0.021) and atrial fibrillation (OR: 0.78; 95% CI: 0.61 to 0.96; p = 0.002) were associated with lower odds of tamponade.

**CONCLUSIONS** The burden of cardiac tamponade associated with PPM implantation has steadily increased in the United States. Specific patient factors were identified that could predict the risk for developing tamponade among PPM recipients. (J Am Coll Cardiol EP 2016;■:■–■) © 2016 by the American College of Cardiology Foundation.

Cardiac perforation resulting in tamponade is a severe complication of permanent pacemaker (PPM) implantations leading to significant morbidity and mortality. Previous studies have estimated the prevalence of cardiac perforation to be 0.1% to 0.8% for PPM implantations (1,2). However, most studies included limited numbers of patients and applied older lead technologies. Therefore, recent large-scale studies evaluating the prevalence and trend of cardiac tamponade are lacking. Moreover, even fewer studies have investigated predictors of in-hospital cardiac tamponade from PPM implantations and their in-hospital outcomes. Knowledge regarding potential predictors of tamponade in this population helps physicians identify patients at highest risk for development of this potentially catastrophic complication and facilitate their decision making.

## ABBREVIATIONS AND ACRONYMS

**DDD** = dual-chamber

**ICD-9-CM** = International Classification of Diseases-Ninth Revision-Clinical Modification

**NIS** = National (Nationwide) Inpatient Sample

**PPM** = permanent pacemaker

Therefore, in the present study, we used data from the National (Nationwide) Inpatient Sample (NIS) to describe the trends of cardiac tamponade among PPM recipients in the United States between 2008 and 2012 and also to determine the predictors of tamponade in this population.

## METHODS

**DATA SOURCE.** The NIS was queried to identify patient demographics and risk profile for PPM recipients in the United States between 2008 and 2012 using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). The NIS contains deidentified patient-level data and is a subset of the Agency for Healthcare Research and Quality. The database is robust and is a nationally representative survey of hospitalizations designed to annually compile a representative sample of hospital discharge records in the United States. It is the largest all-payer inpatient database, representing approximately 20% of all hospitals in the United States, regardless of patient characteristics or payment source. National estimates can be produced using sampling weights provided by the sponsor. Previous studies have shown that the results of the database correlate well with other hospitalization discharge databases in the United States, and therefore it has been used to explain trends in other acute medical and surgical conditions (3).

**STUDY DESIGN AND COHORTS.** The study population included all patients who underwent primary PPM implantation from 2008 to 2012 who are included in the NIS database. ICD-9-CM codes were used to identify the study cohort. Primary procedural codes 37.80 to 37.83 and 00.50 were used to identify the population of PPM recipients. Patients undergoing replacement of any type of PPM device (ICD-9-CM procedural codes 37.85 to 37.89) or insertion or replacement of PPM leads (ICD-9-CM procedure codes 37.75 to 37.77) were excluded from the analysis. The type of PPM implanted was characterized as single-chamber ventricular, dual chamber (DDD), or biventricular. The diagnostic code 423.3 was used to identify patients who developed cardiac tamponade during hospital admission in the PPM population. These ICD-9-CM codes have been consistent during this time period, thereby allowing the analysis of longitudinal trends in the data for prevalence of PPM implantations. The NIS discharge records were queried to identify demographics, including age, sex, race, insurance status, primary and secondary procedures, hospitalization outcome, and length of stay.

The comorbidities associated with tamponade development were identified using Agency for Healthcare Research and Quality comorbidity measures. These comorbidity measures use ICD-9-CM diagnoses to identify different comorbidities on the discharge date. The severity of comorbidities were identified by using the Deyo modification of the Charlson Comorbidity Index (4). This index contains 17 comorbid conditions with differential weights, with a total score ranging from 0 to 33. Higher Charlson Comorbidity Index scores correspond to greater burden of comorbid diseases.

**STATISTICAL ANALYSIS.** Stata IC 13 (StataCorp LP, College Station, Texas) was used for all analyses. For categorical variables, chi-square tests were used, and for continuous variables such as length of stay, Wilcoxon signed rank tests were used, because these variables were not normally distributed. For analysis of trends, the ptrend (using the Cochrane-Armitage test for categorical variables [5]) and nptrend (using the nonparametric test for trend by Cuzick for continuous variables [6]) commands in Stata were used. Hierarchical mixed-effects logistic regression models were generated to determine the independent predictors of tamponade in the PPM population. Two-level hierarchical models (with patient-level factors nested within hospital-level factors) were created using the unique hospital identification number incorporated as random effects within the model. The model included patient-level variables such as age, sex, and comorbidities as well as hospital-level variables such as hospital size (number of beds), hospital region, and teaching status. Choice of covariates for the multivariate analyses was based on the plausibility that they could be associated with cardiac tamponade. A p value <0.05 was considered to indicate statistical significance.

## RESULTS

**BASELINE CLINICAL CHARACTERISTICS.** A total of 922,549 PPM implantations were estimated in the United States between the years of 2008 and 2012. Among these patients, single-chamber ventricular PPMs were implanted in 178,589 patients (17.6%), while 733,638 (72.3%) and 102,486 (10.1%) patients received DDD and biventricular devices, respectively. A total of 2,595 patients (0.28%) developed in-hospital cardiac tamponade during admission. Patients' clinical characteristics and associated comorbidities are shown in Table 1. The mean age of