Fourteen-Year Trends in Pacemaker Implantation in the United States

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Introduction

• The World Survey\(^1\) reported that US patients receive more dual chamber (DDD) pacemakers (PM) compared to Canada and most European nations.

• DDD PM, as a % of total PM volume, increased from 1997-2001.

• BiV PM began to be implanted in 2002.

• We studied the national annual PM implantation rate from 1993-2006.

1. Mond et al., Pacing Clin Electrophysiol 2008; 31(9):1202-1212
Research Questions

• How has the epidemiology of PM utilization evolved over the past 14 years?
• How has hospital resource utilization for PM procedures evolved?
• What are the future implications of historical pacemaker trends?
Hypothesis

• There would be continued growth in DDD and biventricular (BiV) PM, as compared to single chamber (VVI and AAI) PM in the US.
Methods – Historical Trends I

• The Nationwide Inpatient Sample (NIS) was queried to identify PM implants from 1993-2006 using the following ICD-9-CM procedure codes:
  – Dual chamber (DDD) PM: 37.83
  – Single ventricular (VVI) PM: 37.81-82+37.71
  – Single atrial (AAI) PM: 37.81-82+37.73
  – Biventricular (BiV) PM: 00.50*

*New code in 2002
Methods – Historical Trends II

- The NIS is an annual statistically valid survey of ~1,000 hospitals and contains ~20% of hospitalizations within the US regardless of payment source.
- Annual PM implantation rates, changes over time, and patient/procedure attributes were calculated:
  - Mortality
  - Length of stay
  - Inpatient charges/cost (in $2008)
**Statistical Methods**

- Rate of PM implantation indexed by: calendar year, age, sex, & Census regions
- Number of implants in each sub-group assumed to follow a Poisson distribution
- Population in each sub-group was obtained from the US Census Bureau
- Implant rate was modeled by a Poisson regression, adjusting for demographic and temporal differences

- Single Atrial: 0.6%
- Single Ventricular: 22.0%
- BiV (2002+): 1.2%
- Dual Chamber: 76.2%

Total PM Implanted: 2.34 Million
Incidence of Pacemaker Implantation
HCUP NIS Data, 1993-2006

- Dual Chamber: 90,000
- Single Ventricular: 30,000
- Single Atrial: 60,000
- BiV: 120,000
Rates in Pacemaker Implantation

HCUP NIS Data, 1993-2006

<table>
<thead>
<tr>
<th>Procedure Type</th>
<th>Rate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Chamber</td>
<td>+3.6 to +4.1%</td>
</tr>
<tr>
<td>Single Ventricular</td>
<td>-4.4 to -4.9%</td>
</tr>
<tr>
<td>Single Atrial</td>
<td>-2.4 to -4.1%</td>
</tr>
<tr>
<td>BiV</td>
<td>+8.4 to +20.8%</td>
</tr>
</tbody>
</table>

*Temporal Trend Significant: p < 0.0001
Trends in Patient’s Level of Comorbidity

HCUP NIS Data, 1993-2006

The chart illustrates the trends in patient's level of comorbidity over the years from 1993 to 2006, using data from the HCUP NIS. The chart compares the average Charlson comorbidity index across different cardiac conditions:

- Dual Chamber
- Single Ventricular
- Single Atrial
- BiV

The data shows a noticeable increase in the comorbidity index over the years, with significant differences between the categories.
Hospital Trends

• VVI PM were implanted more often in teaching hospitals (51.5%)
• DDD (52%), BiV (65%) and AAI (57.4%) PM were implanted more often in urban non-teaching or rural hospitals ($P<0.001$)
• In hospital survival was 98.6% for DDD patients, similar with BiV (98.3%, $P>0.05$) and higher than VVI (97.8%, OR=1.64, $P<0.001$) and AAI (97.8%, OR=1.71, $P<0.001$)
Trends in Length of Stay in Pacemaker Surgery

HCUP NIS Data, 1993-2006
Inpatient PM Charges v. Costs in 2006
Average Hospital Charge & Cost (HCUP Cost-to-Charge Conversion)
Discussion

• Plateau in DDD PM between 2003-2006, and decrease in % of DDD PM from 2000 to 2006
  – Increased utilization of BiV PMs and implantable cardioverter defibrillators (ICDs)¹

• Strengths
  – Largest nationally representative database
  – Covers all patient ages, payers, hospital types

• Limitations
  – Administrative data
  – Hospitalization only

1. Mond et al., Pacing Clin Electrophysiol 2008; 31(9):1202-1212
Future Implications?

- Although overall totals were presented, historical analysis of surgery rates in sub-populations would provide additional insight.
- Projected sub-population growth
  - US Census
- Projection analysis of surgery rates in sub-populations
  - Poisson regression
  - Point estimates and 95% CI
Future Demand: Projection Methods

• Subpopulation projection =
  – \((\text{projected sub-population}_{\text{year}}) \times (\text{projected rate}_{\text{year}})\)

• National projection
  – Sum of projections for sub-populations
Future Demand for Pacemaker Implantation
HCUP NIS Data, 1993-2006

Potential Future Demand,
*Trend (linear) in Rate Allowed*

# of Implantation Procedures

Future Demand for Pacemaker Implantation
HCUP NIS Data, 1993-2006

700,000
800,000
600,000
500,000
400,000
300,000
200,000
100,000
0

Dual Chamber
Single Ventricular
Single Atrial
BiV
Future Demand for Pacemaker Implantation

HCUP NIS Data, 1993-2006

700,000

800,000

Potential Future Demand, Constant Rate (2002-2006)

Conclusions - I

- DDD PM constitute the vast majority of US implants.
- There was a steady growth in DDD PM implantation in the US from 1993 to 2002, followed by a decline from 2003-2006.
- This decline in DDD PM was associated with an increase in BiV PM (and ICD) implantation rates over the same period.
Conclusions - II

• The decline in VVI PM implantation may be partly due to increasing recognition of harmful effects of RV pacing, although teaching hospitals implanted more VVI PM

• These trends justify scrutiny and periodic updates, and may shed light on future PM implantation rates
Thank You!

• Questions?
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