Modelling the health benefits and economic implications of implanting dual-chamber vs. single-chamber ventricular pacemakers in the UK

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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The use of dual-chamber pacemaker devices (DDD) versus single-chamber ventricular pacemakers (VVI) for the treatment of bradycardia due to sinoatrial node disease or atrioventricular block. Rate-modulated pacemaker systems (DDDR or VVIR) were also considered.

Type of intervention
Treatment.

Economic study type
Cost-utility analysis.

Study population
The study population comprised a hypothetical cohort of patients with bradycardia due to sinoatrial node disease or atrioventricular block.

Setting
The setting was a hospital. The economic study was carried out in the UK.

Dates to which data relate
The effectiveness data were derived from studies published between 2000 and 2003. The dates for resource use were not explicitly stated. The price year was 2003.

Source of effectiveness data
The effectiveness evidence was derived from a synthesis of published studies.

Modelling
A discrete-event simulation was constructed to assess the 5-year costs and benefits of VVI versus DDD in a hypothetical cohort of patients requiring implantation of a pacemaker for the treatment of bradycardia. Each patient could develop postoperative complications, symptoms of pacemaker syndrome (some of which would need replacement of the VVI with a DDD), atrial fibrillation (AF), have a stroke, or die. The simulation considered three key events. Specifically, the detection of AF (requiring anticoagulation or not), the occurrence of an implantation-related complication, and the incidence of pacemaker syndrome. Only patients with permanent AF were candidates for anticoagulation, while paroxysmal and persistent episodes were not. Depending on anticoagulation and other patient characteristics, the risk of stroke was estimated. If implantation-related complications occurred, the model assigned a type of complication and re-operation was required. If pacemaker syndrome occurred, the simulation assessed whether this was sufficiently severe to require upgrading the VVI to a DDD. Patients were removed from the analysis when they
Outcomes assessed in the review
The outcomes estimated from the literature were:

- the baseline demographic and clinical characteristics of the simulated cohort,
- the rate of complications,
- risk functions,
- the incidence of pacemaker symptoms,
- the death rates, and
- the utility scores.

Study designs and other criteria for inclusion in the review
It was not stated whether a systematic review of the literature was undertaken. Baseline characteristics of the patient population were derived from the Canadian Trial of Physiological Pacing (CTOPP), published data on the UK population requiring pacemakers, and the Framingham Heart Study for patients with AF. Other data were mainly derived from two long-term, large clinical trials, (the CTOPP and the Mode Selection Trial in Sinus-Node Dysfunction (MOST)). Some characteristics of the clinical trials were reported, particularly for the CTOPP. Utility data were extrapolated from the MOST study (which used the time trade-off approach).

Sources searched to identify primary studies
Not reported.

Criteria used to ensure the validity of primary studies
The use of clinical trials ensured a high internal validity.

Methods used to judge relevance and validity, and for extracting data
Not reported.

Number of primary studies included
Seven primary studies provided the clinical data.

Methods of combining primary studies
Not reported.

Investigation of differences between primary studies
Not reported.

Results of the review
The baseline demographic and clinical characteristics of the simulated cohort were as follows.

The proportion of men was 58.8%.
The distribution of the patients according to age was 1.2% aged 30 - 39 years, 3.0% aged 40 - 49 years, 7.8% aged 50 - 59 years, 16.6% aged 60 - 69 years, 35.7% aged 70 - 79 years and 35.7% aged 80 - 89 years.

The systolic blood pressure was 145 (+/- 23) mmHg.

In terms of pacing indication, there were 33.7% with sinoatrial nodal disease alone, 59.8% with atrioventricular block alone, and 6.5% were unknown or had both indications.

The proportion of patients with a diagnosis of diabetes was 14.8%.

The proportion of patients with prior stroke or transient ischaemic attack was 9.8%.

The probability of developing an implantation-related complication during the first postoperative month was 2.10% for VVI and 4.8% for DDD. The rate of complications was the same for VVIR and DDDR after the first month, 0.51% for the second month and 1.50% annually thereafter.

DDD reduced the risk of AF by 18%. The proportion of AF becoming chronic was 58.2% for VVI and 52.8% for DDD. Sixty-five per cent of patients with chronic AF received an anticoagulant, with a 0.55% relative risk reduction in stroke.

The incidence of pacemaker symptoms was 38% for VVI. Forty-seven per cent of these patients would switch to a DDD (69% switched in the first 3 months and 73% in the first 6 months).

The utility score before the implant was 0.73, with a 0.05 improvement after implantation of a VVI and a 0.08 improvement after implantation of a DDD after one year.

One year after implantation, the utility score declined by 0.003 with VVI and by 0.004 with DDD.

Measure of benefits used in the economic analysis

The summary benefit measure used was the expected number of quality-adjusted life-years (QALYs). These were estimated by combining utility weights and life expectancy using the discrete-event model. A discount rate of 1.5% was applied for QALYs gained beyond the first year.

Direct costs

The analysis of the costs was carried out from the perspective of the UK NHS. It included the costs associated with the initial implantation and each subsequent clinical event over a 5-year time horizon. The initial costs covered the implantation procedure and pacemaker system. Subsequent costs included anticoagulation therapy (warfarin, physician visits and laboratory tests) and treatment for stroke. The unit costs were reported separately from the resource quantities for a few items only, most costs being presented as macro-categories. The costs were derived using data from the Department of Health and NHS reference costs. The source of the resource use data was not explicitly stated. Discounting was relevant as 5-year costs were considered and an annual rate of 6% was used. The price year was 2003. Where necessary, the costs were inflated using the appropriate consumer price index.

Statistical analysis of costs

Standard statistical analyses of the costs were not carried out. However, model replications were used to generate standard deviations around the total costs of the two alternative strategies.

Indirect Costs

The indirect costs were not considered in the economic analysis.

Currency
Sensitivity analysis
Univariate sensitivity analyses were carried out to assess the robustness of the cost results to variations in key model inputs using ranges of values derived from the literature. Alternatively, the authors used arbitrarily chosen values. The use of alternative discount rates for the costs and benefits was also investigated. Finally, the issue of uncertainty was handled by the use of 100 model replications in a second-order multivariate analysis.

Estimated benefits used in the economic analysis
The expected discounted QALYs over a 5-year time horizon were 3.17 (+/- 0.03) with VVI and 3.26 (+/- 0.04) with DDD (difference 0.09).

Cost results
The expected discounted costs per patient over a 5-year time horizon were 4,255 (+/-61) with VVI and 4,297 (+/-29) with DDD (difference 43).

Synthesis of costs and benefits
An incremental cost-utility ratio was calculated in order to combine the costs and QALYs of the alternative strategies.

The incremental cost per QALY gained with DDD over VVI was 477. The model simulations showed that DDD dominated VVI in 26% of the replications.

The sensitivity analysis suggested that the total costs were sensitive to the proportion of patients with a VVI requiring a replacement device due to pacemaker syndrome. For instance, if only 5% of patients with a VVI requiring a replacement had a second operation, the costs in the DDD group would be 14% higher than those in the VVI group.

Changes in other model inputs did not alter the conclusions of the base-case analysis. The multivariate sensitivity analysis showed that DDD was dominant (more QALYs and lower costs) in 29% of the replications and had an incremental cost per QALY below 1,000 in 31% of the simulations. In no case did the incremental cost per QALY exceed 10,000.

Authors’ conclusions
The implantation of a dual-chamber pacemaker device (DDD) was a cost-effective alternative to single-chamber ventricular pacing (VVI) despite higher initial costs, owing to the reduction in both the risk of atrial fibrillation (AF) and the development of pacemaker syndrome.

CRD COMMENTARY - Selection of comparators
The choice of the comparators appears to have been appropriate given the objective of the study. You should decide whether they are valid comparators in your own setting.

Validity of estimate of measure of effectiveness
The effectiveness evidence was derived from selectively identified studies. It was unclear whether a systematic review of the literature was performed to identify the primary studies. The characteristics of the two main clinical trials were described. In general, the use of clinical trials should have ensured a high internal validity for the clinical estimates used in the model. However, the clinical trials were performed in Canada and their transferability to the UK setting is uncertain. The issue of comparability across the primary studies was not addressed, and details of the approach used to combine the clinical estimates were not reported. Given the uncertainty surrounding some clinical estimates, a sensitivity analysis was carried out, the results of which were extensively reported.
Validity of estimate of measure of benefit
QALYs were the most appropriate benefit measures because they capture the impact of the intervention on both quality of life and survival, which are the most relevant dimensions of health for patients receiving a pacemaker. The utility weights were obtained using the time trade-off approach, which was appropriate, although it was based on Canadian rather than UK patients. QALYs are comparable with the benefits of other health care interventions. Discounting was applied, as recommended by guidelines for economic evaluations.

Validity of estimate of costs
The costs included were consistent with the perspective adopted in the study, thus only direct medical costs were considered. The sources of the data were reported for most items. There was some information on the unit costs but little on resource consumption. A detailed breakdown of the cost items was not given, which limits the possibility of replicating the analysis in other settings. The cost estimates were specific to the study setting and sensitivity analyses were performed (cost estimates varied by +/- 10%). With the exception of the costs of the pacemaker system, the impact of individual costs was not investigated. The price year was reported, which enhances the possibility of carrying out reflation exercises in other time periods. The authors stated that routine follow-up costs were not considered, although some studies suggested that these costs might be higher for DDD systems.

Other issues
The authors stated that their results were consistent with the findings from other economic evaluations. The issue of the generalisability of the study results to other settings was not explicitly addressed, although several sensitivity analyses were carried out, which enhance the external validity of the study. It was pointed out that the clinical data were derived from studies carried out in countries other than the UK, although the authors stated that these studies should be applicable to UK patients. The analysis referred to patients with bradycardia due to sinoatrial node disease or atrioventricular block, and this was reflected in the authors’ conclusions.

Implications of the study
The study results appear to support the use of DDD for the treatment of patients with bradycardia due to sinoatrial node disease or atrioventricular block.

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Other publications of related interest


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