Cryo- and radiofrequency cardiac ablation catheters for the treatment of atrial fibrillation

Report Part 2:

Focused economic evaluation

Focused financial analysis

16 November 2018

Disclaimer:

The focussed economic and financial analyses in this report were informed by the rapid review of high-level clinical evidence to address specific questions posed by the Commonwealth Department of Health. The economic and financial analyses have been prepared using pragmatic methodologies and the results should be considered to be indicative only.

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ABBREVIATIONS

AAD	antiarrhythmic drug
AF	atrial fibrillation
AHRQ	Agency for Healthcare Research and Quality
AT	atrial tachyarrhythmia
CA	cardiac/catheter ablation
CSANZ	Cardiac Society of Australia and New Zealand
HRQoL	health-related quality of life
HTA	health technology assessment
ITT	intention to treat
LOS	length of stay
LV	left ventricular
MBS	Medicare Benefits Schedule
MSAC	Medical Services Advisory Committee
MT	medical therapy
NHFA	National Heart Foundation of Australia
OAC	oral anticoagulant
PBS	Pharmaceutical Benefits Scheme
PHA	Private Healthcare Australia
PHI	Private Health Insurer
PI	Product Information
PL	Prostheses List
PLAC	Prostheses List Advisory Committee
QALY	quality-adjusted life year
QoL	quality of life
RCT	randomised controlled trial
RF	radiofrequency
SR	systematic review
SVT	supraventricular tachycardia

Key findings

Is there sufficient data to establish that the devices are cost effective at the prices currently being paid in Australia?

Based on the data included in the high-level review it appears that neither radiofrequency (RF) ablation catheters nor cryoablation catheters are cost-effective at the prices currently being paid in Australia (namely, average prices of $2,300 for mapping catheters, $6,000 for RF ablation catheters, and $4,065 for cryoablation catheters). The indicative cost-effectiveness of the different types of ablation compared with medical therapy was found to be **$110,321/QALY for RF ablation** and **$95,481/QALY for cryoablation**. It is reasonable to expect that a time horizon of more than one year might generate a lower cost-effectiveness ratio if it can be assumed that patients who experience a reduction in AF symptoms in the short term are ultimately 'cured' by the ablation procedure. The cost-effectiveness of the procedures was most sensitive to the price of the devices.

However, it should be noted that a number of simplifying assumptions have been required to develop the current focused economic evaluation and a more comprehensive economic evaluation might be warranted to generate more reliable estimates of cost-effectiveness. Although some published economic evaluations report that cardiac ablation is cost-effective, these evaluations appear to be driven by the inclusion of outcomes in heart failure patients (who are out of scope for the current consideration) or the assumption that cardiac ablation reduces the rate of subsequent stroke and/or mortality (claims that are not supported by the available clinical evidence).

What is the likely financial impact of listing the devices on the Prostheses List?

The focused financial analysis indicates that the total cost of cardiac catheters (mapping catheters, RF ablation catheters and cryoablation catheters) is currently $44 million to $50 million per year to Private Health Insurers (PHIs), and $24 to $27 million per year to the MBS. The current estimate of costs to PHIs is similar to an estimate from the Department of Health of total PHI outlays for cardiac ablation devices (roughly $43 million), based on data and market share assumptions from a medium size health insurer. If it is assumed that the listing of the devices on the PL generates a 10% increased uptake in the private hospital setting, the **net cost to PHIs is estimated to be $4 million to $5 million per year**, at the **net cost to the MBS is estimated to be approximately $2 million per year**. However, these estimates are highly uncertain.

1 Introduction

On 26 September 2018, the Department of Health engaged a contrator to prepare the following:

- Report Part 1 – A Rapid Review of high-level clinical evidence for cryo- and radiofrequency (RF) cardiac ablation catheters used to treat atrial fibrillation (AF).
- Report Part 2 – A focused economic evaluation to determine whether cardiac catheter ablation is cost-effective at the prices currently being paid in Australia, and a focused analysis of the likely utilisation and budget impact of a decision to list cardiac ablation catheters on the Prostheses List (PL).

1.1 MANAGEMENT OF ATRIAL FIBRILLATION

AF may cause symptoms of palpitations, shortness of breath and fatigue, which often leads to an impaired quality of life. It is also independently associated with an increased long-term risk of stroke, heart failure and all-cause death (NHFA/CSANZ 2018). Although the risk of dying from stroke is reduced by oral anticoagulants (OACs), all-cause mortality and deaths from complications such as heart failure remain high. From a public health perspective, AF places a large and growing burden on healthcare resources, with hospitalisations being the major cost driver (Stewart et al 2004).

The National Heart Foundation of Australia and the Cardiac Society of Australia and New Zealand have recently published *Australian Clinical Guidelines for the Diagnosis and Management of Atrial Fibrillation* (ANHF/CSANZ 2018).[1] Management is primarily aimed at restoring and maintaining sinus rhythm and preventing stroke. For rhythm control, antiarrhythmic drug (AAD) therapy has been the cornerstone of medical management. Although several randomised controlled trials (RCTs) and meta-analyses support the superior efficacy of amiodarone (which has rate and rhythm control properties) over other AADs in maintenance of sinus rhythm, amiodarone is associated with potential long-term toxicities and therefore should not be a first-line treatment choice in patients suitable for other drugs (NHFA/CSANZ 2018).

The Australian guidelines also acknowledge cardiac ablation as an effective procedure for appropriately selected patients with symptomatic AF, particularly those patients who have failed or are intolerant to AADs, or for some patients who decline AAD treatment. The specific recommendations are as follows:

- Catheter ablation should be considered for symptomatic paroxysmal or persistent AF refractory or intolerant to at least one Class I or III antiarrhythmic medication *[GRADE quality of evidence: High; GRADE strength of recommendation: Strong]*
- Catheter ablation can be considered for symptomatic paroxysmal or persistent AF before initiation of antiarrhythmic therapy *[GRADE quality of evidence: Moderate; GRADE strength of recommendation: Strong]*
- Catheter ablation can be considered for symptomatic paroxysmal or persistent AF in selected patients with heart failure with reduced ejection fraction *[GRADE quality of evidence: Moderate; GRADE strength of recommendation: Strong]*

According to the Australian guidelines, patients frequently report a dramatic improvement in quality of life with cardiac ablation. Multiple RCTs have demonstrated higher rates of sinus rhythm maintenance after cardiac ablation compared with AADs, and ongoing studies are continuing to evaluate the potential for stroke and mortality risk reduction in patients with AF. Although published major complication rates range

[1] Guideline available at Heart lung and circulation Accessed 22 October 2018.

from 1% to 7%, the guidelines note that published complication rates for cardiac ablation from experienced Australian institutions have been about 1% (Voskoboinik et al 2018).

1.2 FINDINGS FROM THE CLINICAL REVIEW

1.2.1 Evidence from systematic reviews

The review of high-level clinical evidence found moderate evidence that radiofrequency (RF) ablation is superior to medical therapy for enhancing patient freedom from recurrence of atrial arrhythmias in both the short and long term regardless of type of atrial fibrillation (AF), but re-ablation is common, occurring in up to 54% of patients at 12 months.

Cardiac ablation has a beneficial impact on all-cause mortality in patients with AF; however, this benefit appears to be largely driven by the inclusion in clinical trials of patients with heart failure (who are out-of-scope for the current evaluation). Evidence from observational studies suggests that cardiac ablation may decrease the risk of stroke compared with medical therapy, but this benefit is not seen in RCTs (which are likely underpowered for this outcome).

Hospitalisation is significantly lower in patients who receive cardiac ablation compared with medical therapy. However, these findings are of low certainty because studies do not provide detail regarding reasons for hospitalisation or the extent to which the hospitalisations are for re-ablation procedures or cross-over from medical therapy to ablation.

A comparison of RF ablation versus cryoablation found no significant difference between catheter types in terms of freedom from AF, or risk of stroke or mortality at 12 months' follow up. The incidence of pericardial effusion and cardiac tamponade is higher for RF ablation compared with cryoablation, but this difference may diminish with the use of contact force-sensing RF catheters, which warn the operator when contact force is too high. Although post-procedural phrenic nerve palsy is significantly more common in the cryoablation group, the overwhelming majority of cases resolve within 1 year. Overall, there is no reliable evidence supporting the superiority of one device type over the other.

1.2.2 Recent findings from the CABANA trial

The findings from the high-level clinical evidence is consistent with findings from the landmark *Catheter ABlation vs ANtiarrhythmic Drug Therapy in Atrial Fibrillation* (CABANA) trial, which is yet to be formally published but has recently been reported in a conference presentation.[2] This large RCT (N=2,204) found that cardiac ablation was associated with a significant reduction in recurrence of AF compared with "current state-of-the-art pharmacologic therapy" at a median follow up of approximately four years. Cardiac ablation was also associated with significantly lower rate for the composite outcome of death or cardiovascular hospitalisation. However, there was no statistically significant difference between arms in the primary endpoint of the trial (the composite of all-cause mortality, disabling stroke, serious bleeding, or cardiac arrest) or the individual components of the primary endpoint using an intention-to-treat (ITT) approach.

Despite CABANA being the largest randomised trial of cardiac ablation, and the most comprehensive and inclusive study to show results for outcomes such as mortality, stroke, and cardiac hospitalisation, interpretation of the findings from this trial are confounded by incomplete blinding and high rates of crossover between arms. Nevertheless, the results from this trial, when published in full, will be provide valuable additional evidence to inform the clinical effectiveness and cost-effectiveness of cardiac ablation compared with medical therapy.

[2] Study rationale and design Preliminary findings available at Cabana trial Accessed 11 October 2018.

1.3 CURRENT FUNDING OF CARDIAC ABLATION CATHETERS

Although cardiac ablation services are funded on the Medicare Benefits Schedule (MBS), the catheters used during these procedures do not meet the criteria for listing on Part A of the PL and therefore private health insurers (PHIs) are not obliged to reimburse these devices. Some device companies supply cardiac catheters to hospitals though complex supply and rebate arrangements, which cover a portfolio of products. This is particularly the case in public hospitals and is supported through activity-based funding. Some PHIs provide benefits for some cardiac ablation catheters; however, this cover is generally provided on an *ex gratia* basis and may not cover the entire cost of the device. The extent to which patients are having to cover the cost of cardiac ablation catheters out-of-pocket is unknown. As such, estimation of the net health expenditure impact of listing cardiac ablation devices on the PL is highly uncertain.

The MBS Review noted a steady growth in use of items for cardiac ablation services (items 38287, 38290 and 38293), which the Cardiology Clinical Committee attributed to increasing access to electrophysiologists and evidence supporting ablation as first line treatment. The three cardiac ablation items have been on the MBS for decades and the services did not undergo MSAC evaluation before MBS listing.

2 Development of the focused economic model

A focused economic analysis was performed to compare the direct medical costs and outcomes related to cardiac ablation versus medical therapy (AADs) in patients with AF. The analysis considers the management pathway for 'typical' patients with AF who are likely to undergo cardiac ablation in Australia. The management pathway was informed by the recent ANHF/CSANZ 2018 guidelines for the diagnosis and management of AF, and therefore focuses on patients with symptomatic AF who are refractory or intolerant to at least one Class I or III AAD.

The analysis does not apply to patients with heart failure. A review of the clinical evidence for these patients was out of scope; however, there appears to be a body of evidence suggesting that patients with heart failure may receive additional benefits from cardiac ablation, such as a reduction in mortality and stroke risk compared with medical therapy.

2.1 Literature search for Australian economic evaluations

A literature search was conducted to identify Australian economic analyses of cardiac ablation (see Appendix A for the literature search strategy). No relevant Australian studies were identified.

A number of published economic evaluations of cardiac ablation versus medical therapy were identified from other countries; however, the evaluations included several assumptions that make the results rather optimistic or subject to high levels of uncertainty (Neyt et al 2013). Several models focus on the impact of ablation on stroke prevention, despite a lack of direct evidence from RCTs to support a claim of improvement in this outcome. Likewise, an indirect impact through stroke on mortality should also be regarded with caution. Published cost-utility models incorporate an impact on health-related quality of life (HRQoL) and assume that the impact is maintained long-term. However, RCT evidence to support a long-term HRQoL benefit of cardiac ablation is lacking and study results are often confounded by cross-over between arms. Therefore, many of the published cost-effectiveness analyses could be considered as "hypothetical estimations [that] should be distinguished from evaluations based on reliable evidence" (Neyt et al 2013).

Of note, more reliable economic analyses may be forthcoming in the future based on results from the CABANA trial. The trial protocol states that if the CABANA clinical comparisons show an important clinical benefit for the ablation arm, cost-effectiveness analyses will be performed, with results expressed in terms of cost per additional life year gained, and cost per quality-adjusted life year (QALY), for cardiac ablation relative to medical therapy (Packer et al 2018). Presumably these analyses would be undertaken from the perspective of the health system in the United States.

2.2 Model structure

A simple decision analytic model was developed using data derived from the findings of the clinical evidence review, described in Section 1.2. The key data relate to outcomes of significance for cardiac ablation relative to medical therapy:

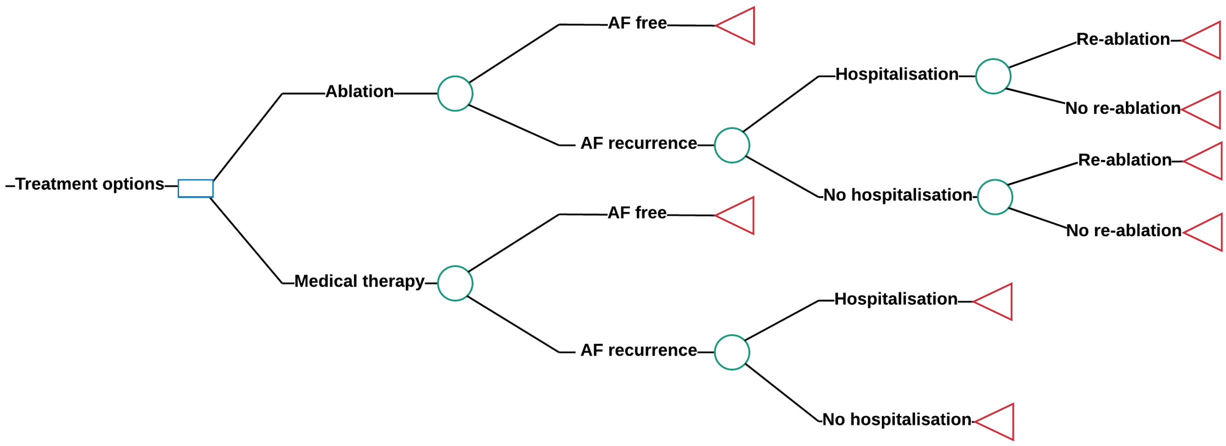
- the rate of AF recurrence rates;
- the rate of cardiac hospitalisation;
- the rate of repeat ablation (cardiac ablation arm only); and
- the rate of major or serious procedure-related complications (cardiac ablation arm only).

The decision tree model structure is illustrated in Figure 1. For simplicity in the approach and interpretation, the model duration is set at 1 year, which was a commonly reported timepoint in RCTs. A longer duration of follow up would inevitably require consideration of crossover in both arms, which commonly occurs in clinical practice but would obscure comparison of the true value of the alternative therapies. Each cycle in the model is one month.

Patients in the model receive initial treatment with either cardiac ablation or medical therapy (i.e. amiodarone) after failure of, or intolerance to, a Class I or III AAD (e.g. flecainide or sotalol). Based on the findings from published systematic reviews, probabilities are assigned for patients in both arms remaining free from AF (normal sinus rhythm) or experiencing a recurrence of arrhythmia. Patients in both arms are at risk of a cardiac-related hospitalisation (of major or minor complexity). Patients in the cardiac ablation arm may undergo repeat ablation, with a success rate that is not dissimilar to the initial procedure.

The model assumes that patients with symptoms of AF have reduced HRQoL, as do patients who experience major or serious complications associated with the ablation procedure, and patients who experience a cardiac hospitalisation. This reduction in HRQoL is captured in the model in a rudimentary manner by applying a utility decrement from a mean norm utility weight for Australians aged 61-70 years.

Figure 1 Decision tree structure



Note: The probabilities applied to the model were derived from a published systematic review rather than an individual study and refer to the entire starting population (i.e. the probabilities are not conditional).

Several important simplifying assumptions were prespecified to enable a focused analysis to be undertaken. Firstly, the model considers cardiac ablation as an alternative to medical therapy and not an add-on. Secondly, the model does not attempt to capture differences in safety or efficacy between the type of cardiac ablation performed (RF ablation or cryoablation), although the difference in costs between the two device types is explicitly considered. As discussed in Section 1.2.1, there is no reliable evidence supporting the superiority of one device type over the other.

Health resource utilisation was modeled to reflect AF management in Australian clinical practice. Estimated unit costs were applied to the resource use, and the total costs were derived as the sum of the initial treatment and follow up. Only direct medical costs were considered and no discounting was applied.

A half-cycle correction was applied to QALYs but not to costs (which are upfront for ablation). Application of the half-cycle correction to costs is likely to have little impact on the results.

A limited number of sensitivity analyses were performed to account for key uncertainties.

2.3 KEY ASSUMPTIONS

2.3.1 Probabilities

The probabilities applied in the model are shown separately in Table 1 for the cardiac ablation and medical therapy arms. The key probabilities that are used in both arms relate to rates of arrhythmia recurrence and cardiac hospitalisation. According to the clinical review (briefly outlined in Section 1.2.1), cardiac ablation was superior to medical therapy for these two outcomes.

Table 1 Probabilities used in the economic model

Assumption	Probability	Source/rationale
Cardiac ablation arm		
Probability of patients receiving CA.	1.0	Assume no aborted procedures.
Probability of patients experiencing serious complications from the CA procedure	0.01	Applies to initial ablation and repeat ablation. Major or serious complication rate of ~1% or 2% is widely acknowledged and includes events such as cardiac tamponade, cardiac perforation, major vascular complication/bleeding, oesophageal haematoma, etc. Australian observational study (Voskoboinik 2018) reported that major or serious complications occurred in 0.84% of patients. Assume patients experiencing serious complications have an extended hospital LOS (additional 6.02 days) based on AR-DRG F16A&B.
Probability that CA procedure will be unsuccessful (no freedom from AF)	0	Australian observational study (Voskoboinik 2018) reported acute procedural success rate was 98.7%. Of note, however, this refers to successful isolation of all four pulmonary veins (entry & exit block) rather than success in terms of impact on AF.
Probability of arrythmia recurrence within 12 months in patients who were free from AF after the initial procedure	0.249	Based on 12-month FU from 8 RCTs in Khan 2018 SR
Probability of patients with recurrence requiring cardiac hospitalisation within 12 months	0.181	Based on 12-month FU from 3 RCTs in Khan 2018 SR
Proportion of downstream cardiac hospitalisations that are of major complexity	0.05	Assumption
Probability that patients will undergo repeat ablation within 12 months	0.20	Re-ablation rate of 20-30% within 12 months according to NHFA/CSANZ 2018 guidelines for the diagnosis and management of AF. Re-ablation rates ranged from 0-53.8% in 8 RCTs with FU 6-12 months (AHRQ 2015).
Probability of arrythmia recurrence within 12 months after repeat ablation	0.20	Assumption. RMH Patient Information states that AF will continue in ~15% of patients with paroxysmal AF and ~30% of patients with persistent AF after 2 procedures.
Medical therapy arm		
Probability of patients receiving MT (amiodarone)	1.0	Assume all patients receive amiodarone (Class III AAD) after failing a Class I AAD.
Probability of arrythmia recurrence within 12 months	0.7216	Based on 12-month FU from 8 RCTs in Khan 2018 SR
Probability of patients requiring cardiac hospitalisation within 12 months	0.580	12-month FU from 3 RCTs in Khan 2018 SR
Proportion of cardiac hospitalisations that are of major complexity	0.05	Assumption

Abbreviations: AAD, antiarrhythmic drug; AF, atrial fibrillation; AHRQ, Agency for Healthcare Research and Quality; AR-DRG, Australian Refined – Diagnosis Related Group; CA, cardiac ablation; CSANZ, Cardiac Society of Australia and New Zealand; FU, follow up; LOS, length of stay; MT, medical therapy; NHFA, National Heart Foundation of Australia; RCT, randomised controlled trial; RMH, Royal Melbourne Hospital; SR, systematic review.

2.3.2 Utility weights

As discussed in Section 2.2, the model assumes that patients 'without AF' have a mean utility weight of 0.737, which reflects the Australian population norm for people aged 61 to 70 years old. A utility decrement of 0.046 is applied to patients 'with AF', and to patients experiencing cardiac hospitalisation. A total decrement of 0.1 is applied to patients who experience major or serious complications from the ablation (or re-ablation) procedure.

Table 2 Utility weights used in the economic model

Assumption	Utility weight	Source/rationale
Decrement in utility weight caused by symptoms of AF	*-0.046*	*Taken from CADTH (Assasi 2010), based on transformed SF-36 responses from the FRACTAL trial (Reynolds 2009). Average change in utility among patients with no documented recurrences of AF over 12 months was 0.046. CADTH claimed this value to best represent the change in utility moving from an AF to a normal sinus rhythm health state (other studies evaluated intervention-specific changes in utility values). Implicitly takes into account AF symptom severity.*
Decrement in utility weight caused by major or serious complications of CA procedure	*-0.1*	*Taken from CADTH 2010.*
Utility weight for person without AF	0.737	Norm mean utility for Australians aged 61-70 years (Norman 2013).
Utility weight for person with AF	0.691	Calculated, based on age-relevant norm
Utility weight for person experiencing major or serious procedure-related complications	0.637	Calculated, based on age-relevant norm

Abbreviations: AF, atrial fibrillation; CA, cardiac ablation; CADTH, Canadian Agency for Drugs and Technologies in Health; SF-36, 36-item Short Form Survey.

2.3.3 Other key assumptions

Other assumptions used in the economic model are shown in Table 3. Several of these assumptions were applied pragmatically in keeping with this 'focused' economic analysis.

Table 3 Other key assumptions used in the economic model

Assumption	Source/rationale
Cardiac ablation arm	
Patients undergoing the CA procedure do not experience improved HRQoL until 1 month after the procedure	Model assumes HRQoL decrement in the first month (while patients are recovering from the procedure) is similar to that of patients with AF. Based on RMH Patient Information stating that ".. it is not uncommon to experience abnormal or irregular heart beat or rhythm for up to 4 weeks after the procedure. Rarely, AF may be worse for a few weeks after the procedure due to inflammation where the ablation was performed."[3]
Arrythmia recurrence is distributed evenly over the duration of the model	Simplifying assumption in lieu of reliable data on time to recurrence in this population.
Patients with arrythmia recurrence cannot transition directly to an 'AF free' state	Simplifying assumption. Patients with arrythmia recurrence are assumed to require an intervention (either hospitalisation or repeat ablation) to restore normal sinus rhythm.
Repeat ablation is distributed evenly over the duration of the model	Simplifying assumption in lieu of reliable data on time to repeat ablation in this population.
Patients who undergo repeat ablation can only transition to an 'AF-free after re-ablation' health state	Re-ablated patients must pass into the 'AF free after re-ablation' state before moving to any other health state in the model. The assumption is that the CA procedure is never unsuccessful (i.e. normal sinus rhythm is restored in all patients, at least for 1 model cycle). This same assumption applies to initial ablation.

[3] Available at Melbourne Heart Rhythm Accessed 07 November 2018.

Assumption	Source/rationale
Patients take an OAC for 3 months immediately before and after the procedure	According to the literature, if not already taking an oral anticoagulant, patients may start treatment 6 weeks before ablation. Some patients may continue taking an oral anticoagulant indefinitely depending on risk of stroke (using $CHADS_2$ score). The model assumes all patients receive warfarin for a 3-month period. Drug costs and INR monitoring costs are incorporated.
Patients in the CA arm do not continue AADs or commence AADs	In practice, a proportion of patients may receive AADs but no reliable Australian data are available to support this.
Medical therapy arm	
All patients (who could otherwise be considered for CA) receive maintenance treatment with amiodarone after failing a Class I or III AAD (flecainide or solatol)	Simplifying assumption, based on NHFA/CSANZ 2018 guidelines for the diagnosis and management of AF (see Figure 2 in Appendix B). Compared with amiodarone, flecainide results in earlier and more effective conversion to sinus rhythm. Amiodarone can be considered for maintenance of sinus rhythm as a second-line agent, or as a first-line agent in patients with LV systolic dysfunction, moderate LV hypertrophy or CAD [*Strong recommendation*]. The dose regimen of amiodarone used in the model is based on the Australian PI.
Patients take an OAC continuously with an AAD	Assumption. Monthly drug costs, INR monitoring costs, and occasional GP visits are incorporated.
Improvement in HRQoL is not immediate on commencement of treatment	Assumes that MT is not immediately effective in controlling AF. This assumption may underestimate the HRQoL benefit of MT.
There is no HRQoL decrement associated with MT	This assumption may overestimate the HRQoL benefit of MT. In reality, patients may experience treatment-related side effects from amiodarone and warfarin that impact on HRQoL.
Arrythmia recurrence is distributed evenly over the duration of the model	Simplifying assumption in lieu of reliable data on time to recurrence in this population.
Patients with arrythmia recurrence cannot transition directly to an 'AF free' state	Simplifying assumption. Patients with arrythmia recurrence are assumed to require an intervention (hospitalisation) to restore normal sinus rhythm.
Patients with arrhythmia recurrence continue amiodarone at the same dose	Assumption. Amiodarone has rate and rhythm control properties. Limited pharmaceutical options are available for patients who convert to persistent (chronic) AF. It is possible that patients remain on treatment because it reduces the frequency of AF attacks (although this was not an outcome captured in the clinical data).

Abbreviations: AAD, antiarrhythmic drug; AF, atrial fibrillation; CA, cardiac ablation; CAD, coronary artery disease; CSANZ, Cardiac Society of Australia and New Zealand; GP, general practitioner; HRQoL, health-related quality of life; INR, international normalised ratio; LV, left ventricular; MT, medical therapy; NHFA, National Heart Foundation of Australia; OAC, oral anticoagulant; PI, Product Information; RMH, Royal Melbourne Hospital; SF-36, 36-item Short Form Survey.

2.3.4 Costs

The cost of ablation is comprised of costs related to preparation for ablation (lead-up consultation and tests), peri-procedural costs (fees for services rendered for imaging, mapping, ablation, anaesthetics, as well as device costs), plus costs relating to theatre use and overnight hospital stay. The cost of repeat ablation is assumed to be the same as for initial ablation. It is assumed that low cost consumables associated with the ablation procedure (e.g. cables, sheaths, needles, etc.) are covered by theatre banding fees.

The imaging and mapping techniques used vary depending on the type of device, ablation approach used and location of the service. The economic analysis assumes that imaging is performed before the ablation procedure using computed tomography (CT), and during the ablation procedure using trans-oesophageal echocardiography.

In the base case economic analysis, it is assumed that one mapping catheter and one ablation catheter is used per ablation procedure. This is likely to underestimate the total cost in the cardiac ablation arm as several mapping catheters may be used during the procedure. The economic analysis considers the cost-effectiveness of the two catheter types separately as the estimated indicative cost of an RF ablation catheter is higher than a cryoablation catheter. For the current analysis, which considers ablation in a private hospital setting, it is assumed that a single mapping catheter (for RF or cryoablation) costs $2,340, an RF catheter costs $6,000 and a cryoablation catheter costs $4,065. These prices are based on information from various sources provided by the Department and are indicative only.

Costs associated with major or severe procedural complications have been captured in the analysis as additional theatre, accommodation and coronary care costs, using the relevant AR-DRG with complications (AR-DRG F16A).

The cost of medical therapy is based on the PBS price for amiodarone and the Australian PI, which provides details of the dose regimen for initiation and maintenance therapy. Patients in the medical therapy arm were assumed to continue taking amiodarone (which has rate and rhythm control properties), together with warfarin, for the full 12 months.

Standard follow up visits and tests were assumed for the cardiac ablation and medical therapy arms as per current clinical practice. Follow up costs also included cardiac hospitalisations.

Table 4 Costs used in the economic model for the cardiac ablation arm

Cost component	Source of unit cost	Rationale/justification	Units	Unit cost ($)[a]	Total ($)[a]
Lead up costs					
Cardiology consultation	MBS item 104	Patients visit the cardiologist on the day before the procedure.	1	73.85	73.85
Blood test (INR)	MBS item 65120	A blood test is required before the procedure to establish that the patients has therapeutic INR levels.	1	11.65	11.65
12-lead ECG	MBS item 11700	Day before procedure	1	26.60	26.60
Cardiac CT	MBS item 56301	Patients are assumed to have a diagnostic contrast chest CT	1	250.75	250.75
Peri-procedural costs					
Pre-anaesthesia consultation	MBS item 17610	Assumes brief consultation with anaesthetist	1	32.75	32.75
Anaesthesia initiation	MBS item 20410	Initiation of management of anaesthesia for electrical conversion of arrhythmias	1	74.25	74.25
Anaesthetist attendance	MBS item 23121	3:51 to 4:00 hours, based on patient information stating that the procedure takes up to 4 hours	1	297.00	297.00
Trans-oesophageal echocardiogram	MBS item 22051	Intra-operative transoesophageal echocardiography to monitor structure and function of the heart chambers, valves and surrounding structures in real time	1	133.65	133.65
Electrophysiology study (mapping) service	MBS item 38212	Intraoperative mapping for RF ablation or cryoablation	1	514.65[b]	514.65[b]
Mapping catheter (single use)	PLAC	Indicative cost to private hospitals for mapping catheter for RF ablation or cryoablation (base case assumes 1 per procedure)	1	2,340.00	2,340.00

Cost component	Source of unit cost	Rationale/justification	Units	Unit cost ($)[a]	Total ($)[a]
Cardiac ablation service	MBS item 38290[c]	Ablation of arrhythmia circuits or foci, or isolation procedure involving both atrial chambers and including curative procedures for atrial fibrillation	1	2,004.00	2,004.00
Ablation catheter (single use)	RF ablation - PLAC	Indicative cost to private hospitals for RF ablation catheter (1 per procedure)	1	6,000.00	6,000.00
	Cryoablation - PLAC	Indicative cost to private hospitals for cryoablation catheter (1 per procedure)	1	4,065.00	4,065.00
Physician assistant	MBS item 51303	Assistance during operation	1	534.40[d]	534.40[d]
Hospitalisation for ablation procedure – no complications	AR-DRG F16B	Accommodation and theatre costs for 'Interventional coronary procs, not adm for AMI, W/O stent implant, minor complications'. Length of stay (according to AR-DRG) is 1.69 days.	0.99	3,457.00	3,422.43
Hospitalisation for ablation procedure – with complications	AR-DRG F16A	Accommodation, theatre and coronary care costs for 'Interventional coronary procs, not adm for AMI, W/O stent implant, major complications'. Length of stay (according to AR-DRG) is 7.71 days.	0.01	7,315.00	73.15
Follow up costs					
Warfarin	PBS code 2211J	Assume all patients receive an OAC for a 3-month period. According to the Australian PI, most patients are satisfactorily maintained at a dose of 2 to 10 mg daily (assume 5 mg/day). General patient charge $22.39, Max. Qty 50 units, 2 repeats.	2	22.39	44.78
INR test	MBS item 65120	Monthly warfarin monitoring.	3	11.65	34.95
GP visits	MBS item 23	GP consultation lasting less than 20 minutes for warfarin monitoring	1	37.60	37.60
Cardiology consultation	MBS item 105	Scheduled visit to cardiologist during follow up (subsequent)	3	37.15	111.45
ECG	MBS item 11700	Twelve-lead ECG, tracing and report during cardiology consultation	3	26.60	79.80
Cardiac hospitalisation (minor complexity)	AR-DRG F76B	Use total cost of hospitalisation for 'arrythmia, cardiac arrest and conduction disorders', with average length of stay 1.67 days	0.1719	1,834.00	315.36
Cardiac hospitalisation (major complexity)	AR-DRG F76A	Use total cost of hospitalisation for 'arrythmia, cardiac arrest and conduction disorders, with average length of stay 6.4 days	0.0091	5,481.00	49.60

Cost component	Source of unit cost	Rationale/justification	Units	Unit cost ($)[a]	Total ($)[a]
Post-hospitalisation cardiology consultation	MBS item 104	Visit to cardiologists after cardiac-related hospitalisation. Assumed to be a new episode of care.	0.181	73.85	13.37
Post-hospitalisation ECG	MBS item 11700	Twelve-lead ECG, tracing and report during cardiology consultation	0.181	26.60	4.81
Lead up costs					**362.85**
Peri-procedural costs		**RF ablation**			**15,426.30**
		Cryoablation			**13,491.30**
Follow up costs					**691.72**
TOTAL		**RF ablation**			**16,480.87**
		Cryoablation			**14,545.87**

Abbreviations: AMI, acute myocardial infarction; AR-DRG, Australian-Refined Diagnosis Related Groups; CT, computed tomography; ECG, electrocardiography; GP, general practitioner; INR, international normalised ratio; MBS, Medical Benefits Schedule; OAC, oral anticoagulant; PBS, Pharmaceutical Benefits Scheme; PI, Product Information; PLAC, Prostheses List Advisory Committee; RF, radiofrequency ablation; W/O, without.
a The unit cost for MBS items refers to the appropriate benefit rather than the Schedule Fee.
b This item has been discounted because the Multiple Operation Rule applies.
c For simplicity, it is assumed that all catheter ablation procedures use the MBS item that is specific for AF ablation in two atrial chambers.
d Calculated as one-fifth of the highest cost procedure.

Table 5 Costs used in the economic model for the medical therapy arm

Cost component	Source of unit cost	Description	Units	Unit cost ($)[a]	Total ($)
Lead up costs					
Cardiology consultation	MBS item 104	Patients visit the cardiologist to initiate treatment with amiodarone. According to the Australian PI, treatment should be initiated in hospital.	1	73.85	73.85
ECG	MBS item 11700	Recommended before starting treatment according to Australian PI.	1	26.60	26.60
Serum potassium and liver function tests	MBS item 66509	Recommended before starting treatment according to Australian PI.	1	13.35	13.35
Thyroid function test	MBS item 66716	TSH quantification, recommended before starting treatment according to Australian PI.	1	21.30	21.30
Medical therapy					
Amiodarone, 200 mg tablet	PBS code 2343H	Assume all patients continue amiodarone for the duration of MT, according to the Australian PI, treatment should be started with 200 mg three times daily and may be continued for one week. The dosage should then be reduced to 200 mg twice daily for a further week. After the initial period the dosage should be reduced to 200mg daily, or less if appropriate. Rarely, the patient may require a higher maintenance dose. General patient charge $24.75, Max Qty 30 units, 5 repeats	13	24.75	321.75

Cost component	Source of unit cost	Description	Units	Unit cost ($)[a]	Total ($)
Warfarin, 5 mg tablet	PBS code 2211J	Assume all patients initiated an oral anticoagulant before starting amiodarone and will continue for the duration of medical therapy. According to the Australian PI, most patients are satisfactorily maintained at a warfarin dose of 2 to 10 mg daily (assume 5 mg/day). General patient charge $22.39, Max. Qty 50 units, 2 repeats.	8	22.39	179.12
Follow up/monitoring					
GP visit	MBS item 23	GP visit lasting less than 20 minutes for monitoring.	4	37.60	150.40
INR test	MBS item 65120	Monthly warfarin monitoring.	12	11.65	139.80
Thyroid function test	MBS item 66716	Regular TSH quantification during treatment with amiodarone, as per Australian PI.	4	21.30	85.20
Hepatic liver function	MBS item 66509	Regular monitoring of liver function during treatment with amiodarone, as per Australian PI.	4	13.35	53.40
ECG	MBS item 11700	According to the Australian PI, regular ECG monitoring is recommended in patients on long-term therapy with amiodarone.	4	26.60	106.40
Ophthalmology test	MBS item 10911	Australian PI for amiodarone recommends regular ophthalmological monitoring (e.g. slit lamp biomicroscopy, visual acuity, ophthalmoscopy) because corneal deposits develop in almost all patients. Assume comprehensive consultation for more than 15 minutes in patients at least 65 years of age.	1	56.80	56.80
Chest X-ray	MBS item 58500	Australian PI for amiodarone recommends that regular chest X-ray should be performed routinely in patients undergoing long-term therapy.	1	30.05	30.05
Cardiac hospitalisation (minor complexity)	AR-DRG F76B	Use total cost of hospitalisation for ‘arrythmia, cardiac arrest and conduction disorders’, with average length of stay 1.67 days	0.5742	1,834.00	519.94
Cardiac hospitalisation (major complexity)	AR-DRG F76A	Use total cost of hospitalisation for ‘arrythmia, cardiac arrest and conduction disorders, with average length of stay 6.4 days	0.0058	5,481.00	172.65
Post-hospitalisation cardiology consultation	MBS item 104	Visit to cardiologists after cardiac-related hospitalisation. Assumed to be a new episode of care.	0.58	73.85	20.94
Post-hospitalisation ECG	MBS item 11700	Twelve-lead ECG, tracing and report during cardiology consultation	0.58	26.60	7.54
Total lead up costs					**135.10**
Total drug costs					**500.87**
Total follow up/monitoring costs					**1,849.79**
TOTAL					**2,485.76**

Abbreviations: AR-DRG, Australian-Refined Diagnosis Related Groups; CT, computed tomography; ECG, electrocardiography; GP, general practitioner; INR, international normalised ratio; MBS, Medical Benefits Schedule; MT, medical therapy; PBS, Pharmaceutical Benefits Scheme; PI, Product Information; PLAC, Prostheses List Advisory Committee; RF, radiofrequency ablation; TSH, thyroid stimulating hormone.

3 Results of the focused economic analysis

3.1 Indicative cost-effectiveness

Indicative total and incremental costs and QALYs per patient are shown in Table 6, together with an estimation of the incremental cost-effectiveness for RF ablation compared with medical therapy, and for cryoablation compared with medical therapy. Cardiac ablation has a much higher up-front cost compared with medical therapy (which is relatively inexpensive). A higher rate of arrhythmia recurrence results in lower total QALYs in the medical therapy arm.

According to the results, the cost-effectiveness of cardiac ablation appears to be above the range usually considered to be cost-effective by MSAC. However, the limitations of the current analysis (refer to Section 3.3) should be taken into account when interpreting these findings. Furthermore, it is reasonable to expect that a time horizon of more than one year might generate a lower cost-effectiveness ratio if it can be assumed that patients who experience a reduction in AF symptoms in the short term are ultimately 'cured' by the ablation procedure. More reliable estimation of cost-effectiveness would require the development of a fully modelled economic evaluation, with extrapolation of outcomes beyond one year, allowance of cross-over between treatment modalities, and the use of conditional probabilities and utility weights from fully verified sources.

Table 6 Indicative cost-effectiveness

Parameter	Cardiac ablation arm	Medical therapy arm	Incremental value
RF ablation			
Cost per patient	$19,550	$2,486	$17,064
QALYs per patient	0.6187	0.4640	0.1547
Cost per additional QALY			**$110,321**
Cryoablation			
Cost per patient	$17,255	$2,486	$14,769
QALYs per patient	0.6187	0.4640	0.1547
Cost per additional QALY			**$95,481**

Abbreviations: QALY, quality-adjusted life year; RF, radiofrequency.

3.2 Sensitivity analyses

Selected one-way and two-way sensitivity analyses were undertaken to test key parameters in the model. The results of these analyses are shown in Table 7. The model is relatively insensitive to all changes in variables (despite the use of a wide range of values for the assumptions), except for the cost of the catheters. When the costs of mapping and ablation catheters are assumed to be $500 each (i.e. the total cost of all catheters for each ablation procedure is $1,000), the indicative incremental cost per QALY for catheter ablation versus medical therapy is approximately $54,031.

Of note, the base case assumes the use of one mapping catheter per procedure, but clinical advice received during the preparation of the current report is that two or three mapping catheters may be used in practice in some patients. The upper bound of this assumption is tested in one of the sensitivity analyses.

Table 7 Sensitivity analyses around uncertain parameters in the economic analysis

Parameter	Base case assumption	Sensitivity assumption	Cost per additional QALY (RF ablation)	Cost per additional QALY (cryoablation)
Base case	-	-	***$110,321***	***$95,481***
Ablation arm				
Lower cost of devices (mapping catheter/ RF catheter/ cryoballoon)	$2,340/ $6,000/ $4,065	$500 each	$54,031	$54,031
Higher number of mapping catheters	1	3	$146,211	$131,372
Higher rate of serious ablation complications	1%	7%	$112,226	$97,369
Higher rate of recurrence/ re-ablation	24.7%/ 20%	30%/ 30%	$119,620	$103,703
Lower rate of re-ablation	20%	9%	$99,104	$85,586
Larger utility decrement associated with serious ablation complications	0.1	0.5	$110,479	$95,618
Lower probability of cardiac hospitalisation within 12 months	18.1%	9.05%	$108,683	$93,866
Larger proportion of major complexity cardiac hospitalisation	5%	50%	$112,586	$97,748
Lower probability of arrythmia recurrence within 12 months after repeat ablation	20%	0%	$110,566	$95,692
Medical therapy arm				
Larger proportion of major complexity cardiac hospitalisation	5%	50%	$102,663	$88,038
Lower probability of cardiac hospitalisation within 12 months	58%	29%	$108,652	$94,544
Both arms				
Increase utility decrement for ablation complications/ major complexity cardiac hospitalisations/ and increase proportion of major cardiac hospitalisations	0.1/ 0.1/ 5%	0.3/ 0.3/ 100%	$97,996	$83,758
Increase utility decrement for ablation complications/ major complexity cardiac hospitalisation/ persons with AF	0.1/ 0.046/ 0.046	0.3/ 0.3/ 0.1	$97,930	$83,702

Abbreviations: AF, atrial fibrillation; QALY, quality-adjusted life year; RF, radiofrequency.

3.3 LIMITATIONS

This focused economic analysis has a number of important shortcomings that limit the interpretation and reliability of results. Importantly, the model is of short duration (12 months) and therefore does not take into account any longer-term benefits that could potentially be attributed to long-term freedom from AF. However, given the limitations in the evidence available, and the requirement to develop this model in a short timeframe, a simple short-term model, without extrapolation, was considered appropriate at this time. One of the clear benefits of a short-term model is that it does not need to take into account inevitable crossover to alternative treatment, which is common in clinical practice. In the CABANA trial, where crossover was permitted, at a median follow up of approximately four years, 9.2% of patients crossed over from ablation to medical therapy and 27.5% crossed over from medical therapy to ablation.

The probabilities applied to the model were derived from a published systematic review rather than an individual study and refer to the entire population in each arm (i.e. the probabilities are not conditional).

The impact of this limitation is that some of the transitions permitted between health states in the model are not entirely logical, despite being possible. For example, patients can transition within one model cycle between 'AF free' and 're-ablation'.

Another limitation of the model is the very simple application of utility weights. Although the utility weights used in the model have been applied in other economic models of treatment for AF, a full literature search and critical appraisal was not conducted to determine the validity of these values.

The full HRQoL benefit of cardiac ablation may be underestimated in the model because ablation may reduce the frequency of AF attacks, which is likely to have a positive effect on patient HRQoL. This is not captured in clinical trials, where freedom from AF is the ultimate measure of treatment success. It can therefore be argued that the utility decrement associated with AF should be smaller in patients who undergo ablation compared with patients on medical therapy. However, the same argument may also apply to medical therapy, given that some patients continue taking AADs despite incomplete resolution of AF symptoms.

The cost of cardiac ablation is indicative only as the cost of the mapping and ablation devices varies depending on the type and complexity of the device and pricing arrangements with hospitals. The model does not capture out-of-pocket costs for patients who may also incur additional charges from the cardiologist and anaesthetist. In some circumstances, patients may be fitted with an implanted loop recorder during the ablation procedure, which is not covered under the MBS for this indication.

Continuous OAC is assumed in the medical therapy arm of the model but only for a 3-month period in the ablation arm. In practice, however, some patients in the ablation arms may recommence OAC on recurrence or may take OAC continuously (depending on $CHADS_2$ score). In both arms, the cost and HRQoL consequences of risks associated with anticoagulation are not explicitly modelled, although these risks may be captured to some extent through downstream cardiac hospitalisations (which are not assumed to be solely dependent on AF recurrence).

Likewise, the model does not capture the cost and HRQoL consequences of adverse events associated with long-term AAD therapy. However, the impact of this omission may not be consequential given that there are real-world data available to indicate that a large proportion of patients who undergo cardiac ablation still take AADs after the intervention (Van Brabandt et al 2012).

Only AF recurrences resulting in cardiac hospitalisation incurred additional cost in the model, likely leading to an underestimate of the cost of medical therapy, since many of those patients would likely seek outpatient care and hence would incur additional costs.

A full economic evaluation could further explore or potentially overcome some of these limitations.

4 Development of a focused financial model

A simple financial model was developed using the same costs captured in the economic analysis (see Section 2.3.4). The financial model considers the impact of a PL listing for cardiac catheters from two main perspectives: PHIs and the MBS. The impact of a PL listing to the Pharmaceutical Benefits Scheme (PBS) and for hospital budgets (public) is also considered, albeit in a cursory manner.

One of the key uncertainties in the analysis is whether the current absence of a PL listing for cardiac ablation catheters is creating any barrier to access for patients, particularly in the private sector. It is not known whether patients are missing out on cardiac ablation altogether due to the absence of explicit funding through the PL, or if some patients are paying significant out-of-pocket expenses for these devices. It is also unclear whether patients who could be managed in the private hospital sector are currently directed to public hospital services to undergo the procedure.

Although the MBS data provide an estimate of current private sector demand, it is not known whether explicitly funding these devices through the PL will drive further private sector demand, either through increased use of cardiac ablation rather than medical therapy, or through a shift in services from a public to a private hospital setting.

As the current amount of PHI subsidy for cardiac ablation is unknown, estimation of the net health expenditure impact of listing cardiac ablation devices on the PL is highly uncertain.

4.1 Approach taken in the financial analysis

The financial analysis is based on projected MBS usage of items relevant to cardiac ablation of AF. Item 38290 is specific to AF and essentially all of its usage is expected to involve cardiac catheter ablation in both atrial chambers. Item 38287 is for single atrial chamber procedures and has a lower fee to reflect this. Although item 38287 is likely to be used for other less complex supraventricular tachycardias, advice received during the preparation of the current report is that a small proportion of services may be for cardiac ablation of AF.

The annual cost of cardiac ablation and the annual cost of medical therapy that were applied to the economic analysis are also applied in the financial analysis (refer to Section 2.3.4). Likewise, the assumptions used in the base case economic analysis for rates of AF recurrence, major or serious procedure-related complications, cardiac hospitalisation, and repeat ablation were applied in the financial analysis (refer to Section 2.3.1). These rates apply to the first 12 months of treatment. Longer term costs are not captured in the financial analysis. The cost of long-term medical therapy is therefore underestimated.

4.2 Key assumptions used in the financial analysis

The additional base case assumptions used in the financial analysis, relating to utilisation and uptake, are summarised in Table 8. As these assumptions are highly uncertain, particularly the estimated increase in the number of patients undergoing cardiac ablation for AF if catheters are included on the PL, they are tested in sensitivity analyses in Section 5.1.3.

The base case analysis assumes that 77% of all cardiac ablation procedures for AF use RF ablation and that the balance of 23% use cryoablation. The base case analysis also assumes that there will be a 10% increase in the number of patients that undergo cardiac ablation if catheters are listed on the PL. The impact of these patients switching from medical therapy to cardiac ablation is factored into the analysis.

Data from Hospital Casemix Protocol 1 (HCP1) collection indicates that 76% of services for item 38290 and 86% of services for item 38287 are privately insured. These proportions are tested in sensitivity analyses.

Table 8 Additional assumptions used in the financial analysis

Assumption	Input	Source/rationale
Proportion of MBS item 38290 services that are used for CA of AF	100%	Assume all use of item is for CA of AF, despite some irregularities in the age distribution of services.
Proportion of MBS item 38287 services that are used for CA of AF	25%	Assume that the majority of use of this service is for less complex SVTs. The age and gender distribution for this item indicates that this is the case.
Relative proportion of all CA services for AF that are RF ablation vs. cryoablation	77%:23%	Relative proportions taken from estimated utilisation provided in applications to PLAC (up to 5000 for RF catheters and up to 1500 for cryoablation catheters).
Estimated increase in number of patients undergoing CA services for AF if catheters are included on the PL list	10%	Assumption. The size of the unmet clinical demand is unknown but information from PHA confirms that CA catheters are currently being covered by at least some PHIs, albeit on a discretionary basis.
Proportion of MBS services that are privately insured services	78%	Data provided by PLAC from Hospital Casemix Protocol 1 collection. A total of 3212/4225 services for 38287 and 3015/3497 services for 38290 were privately insured in 2016-17. Proportion derived from weighting by current services for each item.

Abbreviations: AF, atrial fibrillation; CA, cardiac ablation; MBS, Medicare Benefits Schedule; PHA, Private Healthcare Australia; PHI, private health insurer; PL, Prostheses List; SVT, supraventricular tachycardia.

5 Results of the focused financial analysis

5.1 CURRENT UTILISATION OF CARDIAC ABLATION

The estimated current utilisation of cardiac ablation, based on MBS services, is shown in Table 9. The estimated utilisation relevant to PHIs (privately insured services) is shaded in blue.

The estimated number of procedures is lower but not substantially different from the expected utilisation of these devices noted in PLAC applications (5,000 units for RF ablation and 1,500 for cryoablation). However, the assumptions supporting the estimates in PLAC applications are unknown and may assume an increased demand for cardiac ablation as a result of a PL listing.

Table 9 Estimated current utilisation of cardiac ablation for AF

	Year 1	Year 2	Year 3	Year 4	Year 5
Number of patients					
RF ablation	3,585	3,712	3,838	3,965	4,092
Cryoablation	1,075	1,113	1,152	1,190	1,228
TOTAL	**4,660**	**4,825**	**4,990**	**5,155**	**5,320**
TOTAL – privately insured services	**3,632**	**3,761**	**3,889**	**4,018**	**4,146**
Number of procedures[a]					
RF ablation	4,302	4,454	4,606	4,758	4,911
Cryoablation	1,290	1,336	1,382	1,428	1,473
TOTAL	**5,592**	**5,790**	**5,988**	**6,186**	**6,384**
TOTAL – privately insured services	**4,358**	**4,513**	**4,667**	**4,821**	**4,976**

Abbreviations: AF, atrial fibrillation; RF, radiofrequency.
a The number of procedure is higher than the number of patients because a proportion of patients (20% in the base case) undergo repeat ablation within one year.

5.1.1 Impact of a PL listing on utilisation

The estimated impact of a PL listing on the number of cardiac ablation procedures is shown in Table 10, with blue shading representing estimates of relevance to PHIs.

Information provided by Private Healthcare Australia (PHA) confirms that cardiac ablation catheters are currently being covered by at least some PHIs, albeit on a discretionary basis. This may be as ex gratia payments or other arrangements. Given that patients can already access cardiac ablation procedures through the public system and through at least some privately insured services, there is uncertainty about the size of any unmet clinical demand; that is, how many patients who need cardiac ablation therapy cannot access this under current arrangements. As mentioned in Section 4.2, the base case conservatively assumes that if cardiac catheters were listed on the PL, the number of patients choosing cardiac ablation would increase by 10%.

Table 10 Estimated impact of a PL listing on the number of cardiac ablation procedures for AF

	Year 1	Year 2	Year 3	Year 4	Year 5
Current scenario (no PL listing)					
RF ablation	4,302	4,454	4,606	4,758	4,911
Cryoablation	1,290	1,336	1,382	1,428	1,473
TOTAL	**5,592**	**5,790**	**5,988**	**6,186**	**6,384**
TOTAL – privately insured services	**4,358**	**4,513**	**4,667**	**4,821**	**4,976**
Proposed scenario (PL listing)					
RF ablation	4,732	4,899	5,067	5,234	5,402
Cryoablation	1,420	1,470	1,520	1,570	1,621
TOTAL	**6,151**	**6,369**	**6,587**	**6,805**	**7,022**
TOTAL – privately insured services	**4,794**	**4,964**	**5,134**	**5,304**	**5,473**
Net impact of a PL listing					
RF ablation	430	445	461	476	491
Cryoablation	129	134	138	143	147
TOTAL	**559**	**579**	**599**	**619**	**638**
TOTAL – privately insured services	**436**	**451**	**467**	**482**	**498**

Abbreviations: AF, atrial fibrillation; PL, Prostheses List; RF, radiofrequency.

5.1.2 Financial impact of a PL listing

The estimated financial impact of listing cardiac ablation catheters on the PL is shown in Table 11. Blue shading in the table represents estimates of relevance to PHIs.

The financial impact to the MBS takes into consideration fees for services rendered for consultations, blood tests, imaging, mapping, ablation and anaesthetics.

The financial impact to the PBS is indicative only as the prices used in the analysis refer to the patient charge taken from PBS online, and ongoing pharmaceutical costs after the first year are not taken into consideration.

The financial impact to hospitals primarily relates to public hospitals as the calculations encompass hospitalisation for the ablation procedure and downstream cardiac hospitalisations, using costs derived from AR-DRGs.

The analysis indicates that the total cost of cardiac catheters (mapping catheters, RF ablation catheters and cryoablation catheters) is currently approximately $34 million to $39 million per year for privately insured services. This is similar to an estimate from the Department of Health of total PHI outlays for cardiac ablation devices (roughly $43 million), based on data and market share assumptions from a medium size health insurer. The Department of Health estimate includes outlays for all devices/uses, not just for the treatment of AF.

The net impact of a PL listing shown in Table 11 takes into consideration cost offsets from reduced use of medical therapy after a PL listing. These cost offsets are shown in Table 12.

Table 11 Estimated financial impact of a PL listing

Budget holder	Year 1	Year 2	Year 3	Year 4	Year 5
Current scenario (no PL listing)					
All services					
MBS	$23,685,176	$24,523,814	$25,362,452	$26,201,090	$27,039,729
Cardiac catheters	$44,140,237	$45,703,142	$47,266,048	$48,828,953	$50,391,858
PBS[b]	*$250,410*	*$259,276*	*$268,143*	*$277,009*	*$285,876*
Hospitals[c]	*$21,588,136*	*$22,352,523*	*$23,116,910*	*$23,881,296*	*$24,645,683*
TOTAL	**$89,663,958**	**$92,838,755**	**$96,013,552**	**$99,188,349**	**$102,363,146**
Privately insured services[a]					
MBS	$18,460,331	$19,113,969	$19,767,607	$20,421,246	$21,074,884
Cardiac catheters	$34,403,096	$35,621,231	$36,839,367	$38,057,502	$39,275,638
PBS[b]	*$195,170*	*$202,081*	*$208,992*	*$215,902*	*$222,813*
Hospitals[c]	*$16,825,889*	*$17,421,655*	*$18,017,422*	*$18,613,188*	*$19,208,955*
TOTAL	**$69,884,486**	**$72,358,937**	**$74,833,388**	**$77,307,838**	**$79,782,289**
Proposed scenario (PL listing)					
All services					
MBS	$26,053,693	$26,976,195	$27,898,697	$28,821,199	$29,743,701
Cardiac catheters	$48,554,261	$50,273,457	$51,992,652	$53,711,848	$55,431,044
PBS[b]	*$275,451*	*$285,204*	*$294,957*	*$304,710*	*$314,463*
Hospitals[c]	*$23,746,950*	*$24,587,775*	*$25,428,601*	*$26,269,426*	*$27,110,252*
TOTAL	**$98,630,354**	**$102,122,631**	**$105,614,907**	**$109,107,184**	**$112,599,460**
Privately insured services					
MBS	$20,306,364	$21,025,366	$21,744,368	$22,463,370	$23,182,373
Cardiac catheters	$37,843,406	$39,183,355	$40,523,304	$41,863,252	$43,203,201
PBS[b]	*$214,688*	*$222,289*	*$229,891*	*$237,492*	*$245,094*
Hospitals[c]	*$18,508,478*	*$19,163,821*	*$19,819,164*	*$20,474,507*	*$21,129,850*
TOTAL	**$76,872,935**	**$79,594,831**	**$82,316,726**	**$85,038,622**	**$87,760,518**
Net impact of a PL listing[d]					
All services					
MBS	$1,988,536	$2,058,946	$2,129,355	$2,199,765	$2,270,174
Cardiac catheters	$4,414,024	$4,570,314	$4,726,605	$4,882,895	$5,039,186
PBS[b]	*-$208,364*	*-$215,742*	*-$223,120*	*-$230,498*	*-$237,875*
Hospitals[c]	*$1,613,835*	*$1,670,977*	*$1,728,119*	*$1,785,261*	*$1,842,403*
TOTAL	**$7,808,030**	**$8,084,494**	**$8,360,959**	**$8,637,424**	**$8,913,888**
Privately insured services					
MBS	$1,549,874	$1,604,751	$1,659,629	$1,714,506	$1,769,384
Cardiac catheters	$3,440,310	$3,562,123	$3,683,937	$3,805,750	$3,927,564
PBS[b]	*-$162,400*	*-$168,150*	*-$173,901*	*-$179,651*	*-$185,401*
Hospitals[c]	*$1,257,830*	*$1,302,367*	*$1,346,904*	*$1,391,440*	*$1,435,977*
TOTAL	**$6,085,613**	**$6,301,091**	**$6,516,568**	**$6,732,046**	**$6,947,524**

Abbreviations: AF, atrial fibrillation; MBS, Medicare Benefits Schedule; PBS, Pharmaceutical Benefits Scheme; PHI, private health insurer; PL, Prostheses List.

a Estimate informed by data from the Hospital Casemix Protocol 1 (HCP1) collection provided by PLAC.

b This is an approximation as the prices used in the analysis refer to the patient charge (taken from PBS online)

c These estimates primarily relate to public hospitals as the calculations encompass hospitalisation for the ablation procedure and downstream cardiac hospitalisations, using costs derived from AR-DRGs.

d Net impact takes into consideration the cost offsets from reduced use of medial therapy after a PL listing.

Table 12 Assumed cost offsets from reduced use of medical therapy after a PL listing[c]

Budget holder	Year 1	Year 2	Year 3	Year 4	Year 5
All services					
Number of patients	**466**	**483**	**499**	**516**	**532**
MBS	$379,982	$393,436	$406,890	$420,344	$433,799
PBS[a]	*$233,405*	*$241,670*	*$249,934*	*$258,198*	*$266,463*
Hospitals[b]	*$544,979*	*$564,276*	*$583,572*	*$602,868*	*$622,165*
TOTAL	**$1,158,366**	**$1,199,381**	**$1,240,396**	**$1,281,411**	**$1,322,426**
Privately insured services					
Number of patients	**363**	**376**	**389**	**402**	**415**
MBS	$296,159	$306,646	$317,132	$327,618	$338,105
PBS[a]	*$0*	*$0*	*$0*	*$0*	*$0*
Hospitals[b]	*$181,917*	*$188,358*	*$194,800*	*$201,241*	*$207,682*
TOTAL	**$424,759**	**$439,799**	**$454,839**	**$469,878**	**$484,918**

Abbreviations: AF, atrial fibrillation; MBS, Medicare Benefits Schedule; PBS, Pharmaceutical Benefits Scheme; PL, Prostheses List.
a This is an approximation as the prices used in the analysis refer to the patient charge (taken from PBS online)
b These estimates primarily relate to public hospitals as the calculations encompass hospitalisation for the ablation procedure and downstream cardiac hospitalisations, using costs derived from AR-DRGs.
c These cost offsets have been applied when calculating the net impact of a PL listing in Table 11.

5.1.3 Sensitivity analyses

As several of the assumptions underpinning the financial analysis are highly uncertain, sensitivity analyses were undertaken to test key parameters. The results of these analyses are summarised in Table 13 and relate to privately insured services.

As expected, the assumption of a 50% decrease in the price of cardiac catheters (i.e. prices that would yield more acceptable cost-effectiveness) would result in significant savings to PHIs.

Table 13 Sensitivity analyses around uncertain parameters in the financial analysis

Parameter	Base case assumption	Sensitivity assumption	Impact component (privately insured services)	Net total impact				
				Year 1	Year 2	Year 3	Year 4	Year 5
Base Case	-	-	***Patient numbers***	***363***	***376***	***389***	***402***	***415***
			MBS costs	***$1,549,874***	***$1,604,751***	***$1,659,629***	***$1,714,506***	***$1,769,384***
			PHI costs	***$3,440,310***	***$3,562,123***	***$3,683,937***	***$3,805,750***	***$3,927,564***
			Total costs	***$6,085,613***	***$6,301,091***	***$6,516,568***	***$6,732,046***	***$6,947,524***
Lower catheter price (mapping catheter, RF ablation catheter and cryoablation catheter) after PL listing	$2,340/ $6,000/ $4,065	$1,170/ $3,000/ $2,033	Patient numbers	363	376	389	402	415
			MBS costs	$1,549,874	$1,604,751	$1,659,629	$1,714,506	$1,769,384
			PHI costs	-$15,481,393	-$16,029,554	-$16,577,715	-$17,125,876	-$17,674,037
			Total costs	-$12,836,090	-$13,290,587	-$13,745,083	-$14,199,580	-$14,654,077
Lower proportion of MBS item 38287 services for CA of AF	25%	0%	Patient numbers	287	295	303	310	318
			MBS costs	$1,225,519	$1,258,400	$1,291,282	$1,324,163	$1,357,045
			PHI costs	$2,720,328	$2,793,316	$2,866,304	$2,939,292	$3,012,280
			Total costs	$4,812,026	$4,941,136	$5,070,246	$5,199,355	$5,328,465
Higher estimated increase in number of patients undergoing CA services for AF if catheters are included on the PL list	10%	25%	Patient numbers	908	940	972	1,004	1,037
			MBS costs	$3,874,684	$4,011,878	$4,149,072	$4,286,266	$4,423,460
			PHI costs	$8,600,774	$8,905,308	$9,209,842	$9,514,376	$9,818,909
			Total costs	$15,214,033	$15,752,727	$16,291,421	$16,830,115	$17,368,810
Lower proportion of all CA services for AF that are RF ablation (relative to cryoablation)	77%	50%	Patient numbers	363	376	389	402	415
			MBS costs	$1,549,874	$1,604,751	$1,659,629	$1,714,506	$1,769,384
			PHI costs	$3,213,252	$3,327,026	$3,440,800	$3,554,574	$3,668,348
			Total costs	$5,858,556	$6,065,994	$6,273,432	$6,480,870	$6,688,308
Higher probability that patients who undergo CA will undergo repeat ablation within 12 months	20%	30%	Patient numbers	335	347	359	371	383
			MBS costs	$1,572,655	$1,628,339	$1,684,024	$1,739,708	$1,795,392
			PHI costs	$3,440,310	$3,562,123	$3,683,937	$3,805,750	$3,927,564
			Total costs	$6,155,062	$6,372,999	$6,590,935	$6,808,872	$7,026,809

Parameter	Base case assumption	Sensitivity assumption	Impact component (privately insured services)	Net total impact				
				Year 1	Year 2	Year 3	Year 4	Year 5
Base Case	-	-	***Patient numbers***	***363***	***376***	***389***	***402***	***415***
			MBS costs	***$1,549,874***	***$1,604,751***	***$1,659,629***	***$1,714,506***	***$1,769,384***
			PHI costs	***$3,440,310***	***$3,562,123***	***$3,683,937***	***$3,805,750***	***$3,927,564***
			Total costs	***$6,085,613***	***$6,301,091***	***$6,516,568***	***$6,732,046***	***$6,947,524***
Growth in MBS services	Average increase 2013-2018	15%/year	Patient numbers	404	464	534	614	706
			MBS costs	$1,722,513	$1,980,890	$2,278,023	$2,619,727	$3,012,686
			PHI costs	$3,823,522	$4,397,051	$5,056,608	$5,815,100	$6,687,365
			Total costs	$6,763,484	$7,778,006	$8,944,707	$10,286,413	$11,829,375
Proportion of privately insured services	78%	92%	Patient numbers	429	444	459	474	489
			MBS costs	$1,828,851	$1,893,607	$1,958,362	$2,023,117	$2,087,873
			PHI costs	$4,059,565	$4,203,305	$4,347,045	$4,490,785	$4,634,525
			Total costs	$7,181,023	$7,435,287	$7,689,551	$7,943,814	$8,198,078

Abbreviations: AF, atrial fibrillation; CA, cardiac ablation; MBS, Medicare Benefits Schedule; PHI, private health insurer; PL, Prostheses List; RF, radiofrequency.

6 References

Assasi, N, Blackhouse, G, Xie, F, Gaebel, K, Robertson, D, Hopkins, R, Healey, J, Roy, D, Goeree, R. (2010). Ablation procedures for rhythm control in patients with atrial fibrillation: Clinical and cost-effectiveness analyses. Ottawa: Canadian Agency for Drugs and Technologies in Health (Technology report; no. 128).

Khan, S, Rahman, H, Talluri, S, Kaluski, E. (2018). The clinical benefits and mortality reduction associated with catheter ablation in subjects with atrial fibrillation: a systematic review and meta-analysis. JACC: Clinical electrophysiology. 4(5):626-635.

Khaykin, Y, Wang, X, Natale, A, Wazni, OM, Skanes, AC, Humphries, KH, Kerr, CR, Verma, A, Morillo, CA. (2009). Cost comparison of ablation versus antiarrhythmic drugs as first-line therapy for atrial fibrillation: An economic evaluation of the RAAFT Pilot Study. Journal of Cardiovascular Electrophysiology. 20(1):7-12.

Neyt, M, Van Brabandt, H, Devos, C. (2013). The cost-utility of catheter ablation of atrial fibrillation: a systematic review and critical appraisal of economic evaluations. BMC Cardiovascular Disorders. 13:78.

Packer, DL, Mark, DB, Robb, RA, Monahan, KH, Bahnson, TD, Moretz, K, Poole, JE, Mascette, A, Lee, KL, and the CABANA Investigators. (2018). Catheter ablation versus antiarrhythmic drug therapy for atrial fibrillation (CABANA) Trial: Study rationale and design. American Heart Journal. 199:192-199.

Reynolds, MR, Zimetbaum, P, Josephson, ME, Ellis, E, Danilov, T, Cohen, DJ. (2009). Cost-effectiveness of radiofrequency catheter ablation compared with antiarrhythmic drug therapy for paroxysmal atrial fibrillation. Circulation: Arrhythmia and electrophysiology. 2(4):362-369.

Skelly, A, Hashimoto, R, Al-Khatib, S, Sanders-Schmidler, G, Fu, R, Brodt, E, McDonagh, M. (2015). Catheter ablation for treatment of atrial fibrillation. Technology Assessment. AHRQ Publication. Rockville, MD: Agency for Healthcare Research and Quality.

Stewart, S, Murphy, N, Walker, A, McGuire, A, McMurray, JJV. (2004). Cost of an emerging epidemic: an economic analysis of atrial fibrillation in the UK. Heart. 90(3):286-92.

Van Brabandt, H, Neyt, M, Devos, C. (2012). Catheter ablation of atrial fibrillation. Health Technology Assessment (HTA). Brussels: Belgian Health Care Knowledge Centre (KCE). KCE Report 184C.

Voskoboinik, A, Sparks, PB, Morton, JB, Lee, G, Joseph, SA, Hawson, JJ, Kistler, PM, Kalman, JM. (2018). Low rates of major complications for radiofrequency ablation of atrial fibrillation maintained over 14 years: a single centre experience of 2750 consecutive cases. Heart, Lung and Circulation. 27:976-983.

Appendix A LITERATURE SEARCH STRATEGY

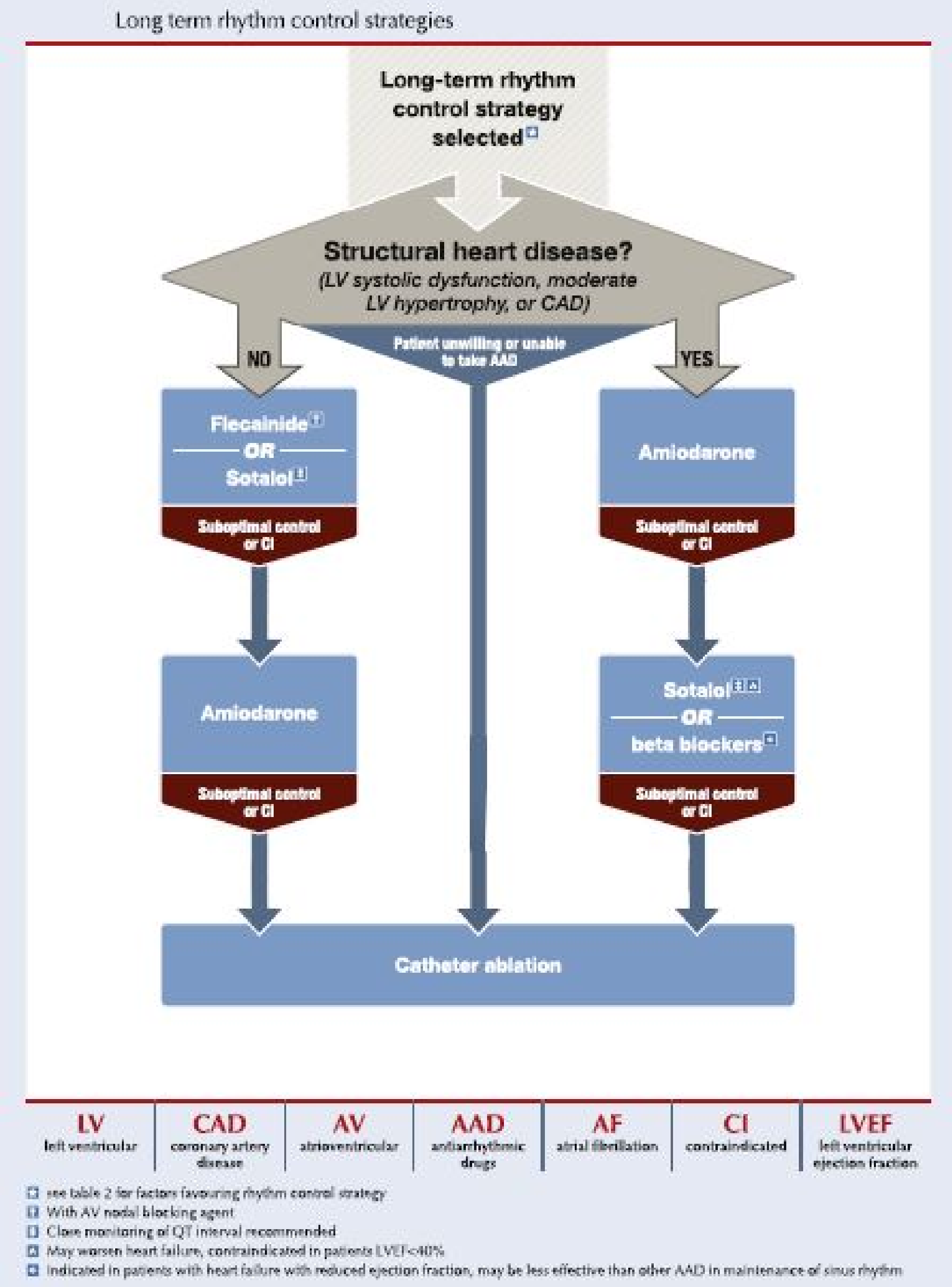
Table App 1 Databases and search strings

Database	Search date	Search string	Records screened
EMBASE.com (concurrently searches Medline and EMBASE)	26 Sept 2018	('atrial arrhythmi*' OR 'atrial fibrillat*' OR 'atrium fibrillat*') AND ((catheter AND (ablation OR isolation)) OR cardiac AND (ablation)) AND 'cost effectiveness analysis'/exp OR 'cost effectiveness analysis' OR 'economic evaluation'/exp OR 'economic evaluation' OR 'health economics'/exp OR 'health economics' OR 'cost minimization analysis'/exp OR 'cost minimization analysis' OR 'cost minimisation analysis' OR 'cost utility analysis'/exp OR 'cost utility analysis' OR 'quality adjusted life year'/exp OR 'quality adjusted life year' OR 'qaly'/exp OR 'qaly' OR 'life year saved' *Filters:* Publication year – 2010 to 2018	228
HTA Database – University of York Centre for Reviews and Dissemination University of York	26 Sept 2018	(atrial arrhythmi* OR atrial fibrillat*) AND (cardiac ablation OR catheter ablation OR catheter isolation OR cryoablation) *Filters:* Publication year – 2012 to 2018	11

Abbreviations: HTA, Health Technology Assessment; NHS, National Health Service.

Appendix B AUSTRALIAN GUIDELINES FOR CARDIAC ABLATION

Figure 2 Long term rhythm control strategies recommended in ANHF/CSANZ guidelines 2018



Source: Australian atrial fibrillation guidelines (ANHF/CSANZ 2018), p1231.
Abbreviations: CSANZ, Cardiac Society of Australia and New Zealand; NHFA, National Heart Foundation of Australia.