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ORIGINAL ARTICLE

Atrial Fibrillation Surgery in Australia: Are We Doing Enough?

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Aim This study aimed to examine contemporary burden and treatment trends of atrial fibrillation (AF) in patients undergoing cardiac surgery in Australia and New Zealand. This allows comparison of contemporary practice with the Society of Thoracic Surgeons guideline recommendations for the surgical treatment of AF in patients undergoing cardiac surgery.

Method A 10-year retrospective review of the Australian & New Zealand Society of Cardiac & Thoracic Surgeons National Cardiac Surgery Database was performed, examining all adult cardiac surgery patients from 2011 to 2021. Patients were grouped by the presence or absence of AF, and simple descriptive statistical analysis was performed to assess baseline demographics and premorbid condition of the patients. The incidence of AF was analysed by type of surgery. Trends for surgical treatment of AF were then analysed using simple descriptive statistics, examining isolated left atrial appendage ligation, isolated surgical ablation, and combined ligation and ablation.

Results In the last 10 years, the Australian & New Zealand Society of Cardiac & Thoracic Surgeons database has recorded 140,680 patients who underwent cardiac surgery. Atrial fibrillation (AF) was present in 21,077 patients (14%). Patients with AF were generally older (72.25 vs 66.65 years; $p<0.001$). Among patients undergoing cardiac surgery, AF was more common in female than in male patients (18% vs 13%, respectively). Patients with AF more often had a higher classification of dyspnoea according to the New York Heart Association and lower ejection fractions compared with their AF-free counterparts. The incidence of AF as a comorbid condition was more frequent in patients undergoing mitral valve surgery or combined coronary artery bypass grafting and valve surgery (aortic, mitral, or both) compared with those undergoing isolated coronary or aortic surgery. Only 11.90% (n=2,509) of patients with AF received a combined ablation and left atrial appendage ligation, and 19.54% (n=693) of those received a Cox-Maze IV ablation.

Conclusions The burden of concomitant AF in patients undergoing cardiac surgery in Australia is higher than previously reported (14% vs 5%–11%). Despite strong recommendation for the surgical management of AF in patients undergoing cardiac surgery and clear evidence of its benefit, both left atrial appendage ligation and surgical ablation independently or concomitantly remain heavily underutilised in this cohort.

Keywords Atrial fibrillation • AF • Cardiothoracic Surgery • Surgical Ablation • Left atrial appendage ligation

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Introduction

Atrial fibrillation (AF) is a common comorbidity found in patients undergoing cardiac surgery. As an isolated pathology, it is present in 2.5%–4% of the population, which has slowly increased over time from 1% to 2% previously [1]. Increasing age, hypertension, diabetes mellitus, obesity, non-alcoholic steatohepatitis, and alcohol consumption are all associated with increasing risk of AF. In Australia, there is a rising prevalence of these risk factors and the metabolic syndrome, each of which are intimately related with the development of atherosclerosis and consequently coronary artery disease. Thus, the burden of AF in cardiac surgery patients is likely to increase [2,3].

Concurrently, the incidence of AF in patients undergoing cardiac surgery is 5%–11%. However, there are specific cardiac pathologies that are more commonly associated with AF [4]. For example, up to 30% of patients undergoing surgery for mitral valve disease will have concomitant AF, while only 14% of patients with aortic valve disease and 6% of patients with isolated coronary disease will have concomitant AF. In 2017, the Society of Thoracic Surgeons (STS) produced a consensus guideline that recommended concomitant surgical AF ablation and left atrial appendage (LAA) ligation to cardiac surgical patients with preoperative AF, noting no significant increase in operative risk [5].

AF, albeit common, is not a benign arrhythmia. AF may be asymptomatic or symptomatic, with varying levels of impairment of quality of life. The presence of AF carries an increased risk of tachycardia-induced cardiomyopathy and embolic stroke, and is associated with elevated risk of congestive cardiac failure, acute myocardial infarction, and all-cause mortality [6]. The risk of embolic stroke with AF has been stratified with risk-calculating tools such as the CHA_2DS_2-VASc score to determine the need for anticoagulation [6]. Most (90%) of AF-related embolic strokes have been identified to have originated in the LAA. Reduction of embolic stroke risk in AF can be achieved by the following three methods: anticoagulation therapy, percutaneous LAA exclusion, and surgical LAA ligation.

Ligation of the LAA during cardiac surgery is a technically simple procedure that can be used to occlude the LAA. Direct comparison of LAA ligation with oral anticoagulation therapy in cardiac surgery patients showed a reduction in embolic stroke from 7% without LAA ligation to 4.8% with LAA ligation (p=0.001; confidence interval [CI] 0.53–0.85) without a change in mortality between the groups [7]. A meta-analysis comparing the use of oral anticoagulation and LAA ligation demonstrated a significant reduction in all-cause mortality, cardiovascular death, and nonprocedural bleeding with LAA ligation, particularly in patients aged over 75 years [8]. Anticoagulation itself in comorbid populations carries a risk of life-threatening bleeding, which has been stratified using the HAS-BLED scoring system [9]. LAA ligation demonstrated superior efficacy in preventing embolic stroke compared with placebo and antiplatelet therapy [8,10]. This suggests that LAA ligation poses little harm as a concomitant procedure, without changing overall mortality.

The STS guidelines also recommend performing surgical ablation without additional risk of morbidity or mortality in the presence of AF during mitral valve surgery (Class IA recommendation) and other cardiac surgeries (Class IB recommendation). Class IA and IB recommendations indicate that there is strong evidence of benefit to the intervention, and that it should be used in most patients. The STS also recommends performing LAA ligation in patients with AF undergoing any cardiac surgery or ablation surgery as a Class IIA recommendation, implying that it is reasonable to treat the appendage in most patients [5].

It has been demonstrated that catheter-based ablation is superior to pharmacological management of AF. Meta-analysis of catheter-based ablation versus surgical ablation has demonstrated superior efficacy in restoring sinus rhythm with surgical ablation, with similar rates of stroke and procedure-related tamponade [11]. However, the periprocedural risk of developing heart block and the subsequent need for a pacemaker is higher with surgical ablation compared with medical or catheter-based therapy. The standalone Cox-Maze (CM) IV procedure has been shown to produce AF-free survival in 88% of patients at 7 years [12]. At 1 year, 85% of patients following a CM procedure were AF- and antiarrhythmic drug-free, and the annual incidence of stroke after CM is 0.2% despite cessation of antiarrhythmic drugs [13]. When comparing patients undergoing cardiac surgery, the operative mortality and morbidity with concomitant CM were similar to those observed with cardiac surgery without CM. However, those undergoing CM, compared with those with surgically untreated AF, had a survival benefit at 10 years (63% vs 42%) [13].

Consistent with the STS guidelines, there is clear evidence of the benefit of surgical treatment of AF with LAA ligation and surgical ablation.

According to review of the 2020 Australian & New Zealand Society of Cardiac & Thoracic Surgeons (ANZSCTS) annual report, over 2,000 isolated mitral valve surgeries were performed, while only 379 surgical ablations and 376 LAA ligations were performed across all cardiac surgery. The incidence of preoperative AF is reported to be as high as 5% in the general population, up to 10% in cardiac surgery patients, and even higher in the presence of mitral valve disease. This is important to acknowledge, as preoperative AF has been demonstrated to increase the risk of in-hospital mortality and major morbidity (stroke, re-operation, wound complications). The incidence of AF in the 2021 report is not stated, suggesting potential underutilisation of the procedures [14].

Aims

This study had the following aims:

1. To understand the burden of AF in cardiac surgery patients in Australia

2. To compare the Society of Thoracic Surgeons 2017 Clinical Practice Guidelines for the Surgical Treatment of Atrial Fibrillation with the contemporary treatment of AF in Australian cardiac surgery

Methods

We performed a retrospective review of the ANZSCTS National Cardiac Surgery Database (a prospectively collected database). All adult patients (aged >18 years) undergoing cardiac surgery from 1 January 2011 to 31 December 2021 were included. Those undergoing paediatric surgery (aged <18 years) and those with cardiac tumours, acute aortic syndrome, or percutaneous interventions were excluded.

There were very low rates of missing data for the variables analysed in this article (<1%). No methods of imputation were used, and the data were analysed as presented.

Definitions of each key data point can be found in the ANZSCTS National Cardiac Surgery Database (Data Definitions Manual Versions 3 and 4) (Appendices 1 and 2). The database transitioned from Version 3 to 4 on 1 September 2016, and data entry/definitions in the database reflect this. Importantly for this analysis, Version 3 did not include LAA ligation or CM IV in the data collection. Before 1 September 2016, LAA ligation was coded to reflect the management of LAA during any concomitant ablative surgery that included LAA ligation as part of its technical description. However, any isolated LAA ligation performed outside of this context before 1 September 2016 is not assessable/recorded.

Statistical Methodology

All statistical analyses were conducted using Stata 17 statistical software (StataCorp, College Station, TX, USA).

Simple descriptive statistics (Mann–Whitney *U*) were used to assess the baseline characteristics of the participants. For this study, patients were split into two groups: those with AF (labelled "AF") and those without AF (labelled "No AF"). Mean and standard deviation or median and interquartile rage were used to describe continuous variables. Categorical variables were analysed and displayed as proportions/frequencies.

Changes since the introduction of the 2017 STS guidelines were examined by chronologically splitting the patients by date of surgery.

Results

Premorbid Condition

Over the last decade, 140,680 cardiac surgeries were recorded in the ANZSCTS database, among which 20,177 patients had preoperative AF. The baseline demographics are displayed in Table 1. Patients with AF were consistently older than their counterparts (72.25 vs 66.65 years, $p<0.001$). Females undergoing cardiac surgery had higher rates of AF compared to males (18.11 vs 13.88%; $p<0.001$).

The premorbid status of patients in the two groups was largely similar with respect to hypertension, body mass index, end-stage renal failure (dialysis), mild to moderate lung disease, infective endocarditis, preoperative myocardial infarction, and clinical urgency.

However, patients with AF had a lower mean preoperative estimated glomerular filtration rate of 71.31 mL/min/1.73m^2 (52.62–93.86) compared with those without AF (84.33 mL/min/1.73m^2 [63.71–108.56]) ($p<0.001$). Similarly, premorbid presence of cerebrovascular disease independent of type (transient ischaemic attack/cerebrovascular accident) was approximately 6% higher in those with AF ($p<0.001$).

Those with AF had a higher classification of dyspnoea according to the New York Heart Association (NYHA) and a lower left ventricular ejection fraction (LVEF) preoperatively.

Mitral valve disease and AF

In all mitral valve surgeries performed, 36.57% of patients with mitral disease also had AF. It was consistently observed that the presence of mitral valve disease and surgery was associated with higher rates of AF compared with surgeries without mitral valve involvement, such as isolated coronary disease (6.78%) and aortic valve replacement (AVR) (14.23%), as demonstrated in Table 2.

Rheumatic disease and AF

A diagnosis of rheumatic valvular disease was present in 8.27% of the population with AF, as opposed to 1.64% of patients without AF. Of the 3,703 patients with rheumatic heart disease (RHD), 47% had AF, as opposed to only 23% of patients with nonrheumatic valvular disease. Furthermore, of the 3,703 patients with RHD, 3,701 (99%) had mitral valve involvement (Table 3).

Treatment of AF

Table 4 demonstrates the surgical treatment of AF over the last decade. Concerningly, despite 21,077 cases of AF being recorded in 140,680 operations, only 2,509 (11.90%) have had concomitant AF ablation and LAA ligation. Of the 21,077 patients with AF, 16,363 (77.63%) have undergone cardiac surgery without an LAA ligation, and 17,532 (83.18%) without receiving an ablation. Even in higher-risk subgroups such as those with mitral valve disease and AF, approximately 66% of patients did not have their LAA treated, and 74% of patients did not receive any form of antiarrhythmic surgery (Table 5).

The change in practice since the 2017 STS guidelines is demonstrated in Table 6. LAA ligation has increased from 13.93% of patients with AF to 52.59%. While the overall rate of surgical ablation in patients with AF decreased (21.4% vs 17%), there has been an uptake of newer ablation techniques, with the CM IV increasing from 3% of ablations before 2017 to 36.54% ($p<0.001$) after 2017, while the CM III expectedly decreased. Unfortunately, only 1,467 (12.5%) of 11,760 patients with AF received combined ablative and LAA ligation surgery after the change in guidelines (vs 11.19% before). Table 7 compares the ablative surgeries performed with and without LAA ligation.

Table 1 Baseline characteristics.

Characteristic	No AF n=119,603	AF n=21,077	P-value
Age (years)	66.65 (57.79–74.02)	72.25 (64.66–78.18)	<0.001
Sex (male, n=103,963)	89,538 (86.12%)	14,425 (13.88%)	<0.001
Sex (female, n=36,719)	30,068 (81.89%)	6,651 (18.11%)	<0.001
Hypertension	85,758 (71.75%)	15,184 (72.06%)	0.35
BMI	28.08 (24.97–31.77)	27.92 (24.62–31.91)	<0.001
Diabetes	36,038 (30.15%)	5,550 (26.34%)	<0.001
Hypercholesterolaemia	79,523 (66. 54%)	12,284 (58.30%)	<0.001
eGFR (mL/min/1.73m^2)	84.33 (63.71–108.56)	71.31 (52.62–93.86)	<0.001
Dialysis	1,911 (1.60%)	424 (2.01%)	<0.001
Previous LAA closure	9 (0.01%)	26 (0.12%)	<0.001
Cerebrovascular disease	11,012 (9.21%)	3,181 (15.10%)	<0.001
Lung disease	15,556 (13.02%)	3,761 (17.85%)	<0.001
Mild	10,664 (68.61%)	2,598 (69.19%)	
Moderate	3,562 (22.92%)	965 (25.70%)	
Severe	1,317 (8.47%)	191 (5.09%)	
Preoperative MI	41,294 (34.54%)	4,859 (23.06%)	<0.001
NSTEMI	29,763 (72.08%)	3,429 (70.57%)	
STEMI	9,028 (21.86%)	917 (18.87%)	
NYHA Class			<0.001
I	49,238 (41.34%)	4,787 (22.78%)	
II	43,498 (36.53%)	7,709 (36.69%)	
III	21,333 (17.91%)	6,831 (32.51%)	
IV	5,030 (4.22%)	1,684 (8.01%)	
Perioperative shock	2,114 (1.77%)	561 (2.66%)	<0.001
Infective endocarditis	3,588 (3%)	908 (4.31%)	<0.001
Preoperative ejection fraction			<0.001
Normal - >60%	60,465 (51%)	8,916 (43.01%)	
Mild impairment - 46%–60%	38,155 (32.63%)	7,056 (34.04%)	
Moderate impairment - 30%–45%	14,129 (12.08%)	3,564 (17.19%)	
Severe impairment - <30%	4,178 (3.57%)	1,195 (5.76%)	
Surgical urgency			<0.001
Elective	80,542 (67.34%)	15,669 (74.34%)	
Urgent	33,348 (27.88%)	4,631 (21.97%)	
Emergent	5,367 (4.49%)	723 (3.43%)	
Salvage	342 (0.29%)	54 (0.26%)	
Mitral valve surgery (all)	12,948 (10.83%)	7,466 (35.42%)	<0.001
Isolated MVR	6,317 (5.28%)	2,141 (10.16%)	<0.001
CABG+MVR	2,850 (2.39%)	1,142 (5.42%)	<0.001
CABG+MVR+AVR	3,170 (2.65%)	1,584 (7.52%)	<0.001
CABG	80,672 (67.47%)	9,085 (43.10%)	<0.001
Isolated CABG	66,179 (55.33%)	4820 (22.87%)	<0.001
CABG+valve	10,901 (9.11%)	2,458 (11.66%)	<0.001
Rheumatic valvular disease	1,959 (1.64%)	1,744 (8.27%)	<0.001

Abbreviations: AF, atrial fibrillation; BMI, body mass index; eGFR, estimated glomerular filtration rate; LAA, left atrial appendage; MI, myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; STEMI, ST-elevation myocardial infarction; NYHA, New York Heart Association; MVR, mitral valve repair/replacement; CABG, coronary artery bypass grafting; AVR, aortic valve replacement.

Treatment patterns in the presence of mitral valve disease differed compared with the trend across the entire cohort (Table 5). In patients with mitral valve disease and AF (n=7,466), 32% of patients had their LAA ligated, while in the entire cohort of patients with AF (n=21,077), only 22.37% of patients had the LAA treated. Furthermore, 19.71% of

Table 2 Burden of AF by surgery type.

Surgery type	Total cases (n)	No AF	AF	P-value
Isolated coronary surgery	70,999	66,179 (93.21%)	4,820 (6.78%)	<0.001
Isolated valve surgery	31,643	24,343 (70.93%)	7,300 (23.07%)	<0.001
MVR	8,458	6,317 (74.69%)	2,141 (25.31%)	<0.001
AVR	14,558	12,487 (85.77%)	2,071 (14.23%)	0.007
Mitral surgery (all)	20,414	12,948 (63.43%)	7,466 (36.57%)	<0.001
Combined coronary and valve surgery	13,359	10,901 (81.60%)	2,458 (18.40%)	<0.001
CABG+AVR	9,027	7,815 (86.57%)	1,212 (13.43%)	<0.001
CABG+MVR	4,001	2,859 (71.46%)	1,142 (28.54%)	<0.001
CABG+AVR+MVR	4,754	3,170 (66.69%)	1,584 (33.32%)	<0.001
Aortic surgery	11,537	9,870 (85.55%)	1,667 (14.45%)	0.094

Abbreviations: AF, atrial fibrillation; MVR, mitral valve repair/replacement; AVR, aortic valve replacement; CABG, coronary artery bypass grafting.

patients with mitral valve disease and AF had an ablation and LAA ligation, while only 11.90% of patients with AF (irrespective of mitral disease) had an ablation and LAA ligation. Table 6 examines the treatment of AF in the presence of mitral disease since the change in guidelines, which showed that despite the strong recommendations for ablation and LAA ligation in 2017, there has been no real change in the utilisation of ablative surgery. The data show that there has been a significant increase in the rate of LAA ligation in this cohort. However, with only 19.73% of appropriate patients receiving an LAA ligation before 2017, as opposed to 43% thereafter, it is unclear if this is a true change or simply a reflection of database coding changes, as discussed in the Limitations section.

Discussion

The Australian cardiac surgery population has higher than expected rates of concomitant AF, at 14.99% as opposed to the 5%–11% in the quoted literature [5]. The data presented herein suggest that AF surgery has historically been underutilised over the last decade, and despite the change in international guidelines to support concomitant AF surgery, it remains underperformed. The higher than expected rates of AF in this cohort can be attributed to several factors. These include a noted global increase in the incidence of AF in the general population of 33% over the last 20 years, a disproportionately high prevalence of RHD and consequently valvular disease in Australia and New Zealand compared with other developed countries [15,16], and a doubling of hospitalisations due to AF in Australia over the last 15 years. Some elements of this increase in incidence may be due to increased awareness, increased preoperative diagnosis, and changes in the health care infrastructure over the last decades [17]. To fully understand the differences in this data set for Australia and New Zealand, a comparative meta-analysis using contemporary international registries is required.

Interestingly, the presence of AF was associated with a higher classification of dyspnoea according to NYHA and lower LVEF. While it is beyond the scope of this data set to explain this, it perhaps reflects the pathophysiological cardiac dysfunction that AF produces, such as the loss of atrial transport function. Conversely, the presence of dyspnoea itself may be a symptom of AF [18]. Equally, prolonged AF can produce tachyarrhythmic cardiomyopathy, and may explain the lower LVEF [19]. Irrespective of the pathophysiology behind this trend, it re-enforces that AF is not benign and should be addressed.

When examining the rates of AF by operation, it is apparent that AF is significantly more common in the presence of mitral valve disease. The incidence of AF was 25.31% in isolated mitral valve surgery, 28.8% in combined coronary artery bypass grafting (CABG)+mitral valve replacement (MVR) (28.80%), and 21.01% in CABG+AVR+MVR, as opposed to 6.78% in isolated coronary surgery. In patients undergoing isolated AVR, CABG+AVR, and isolated aortic

Table 3 Rheumatic valvular disease burden and AF.

Variable	Number of procedures (n)	No AF	AF	P-value
Valve surgery	n=65,661	44,589 (76.66%)	14,011 (23.24%)	<0.001
Rheumatic disease	n=3,703	1,959 (52.1%)	1,744 (47.1%)	<0.001
Nonrheumatic disease	n=54,929	42,244 (76.9%)	12,685 (23.1%)	<0.001

Abbreviation: AF, atrial fibrillation.

Table 4 Surgical AF treatment; ligation, ablation, lesion set, and energy source.

Variable	No AF n=119,603	AF n=21,077	P-value
Antiarrhythmic surgery	451 (0.38%)	3,545 (16.82%)	<0.001
Cox-Maze III	91 (17.95%)	1,136 (32.04%)	
Radial	2 (0.39%)	21 (0.59%)	
Mini-Maze	27 (5.33%)	121 (3.41%)	
LA reduction	29 (5.72%)	127 (3.58%)	
PVI	167 (32.94%)	965 (27.21%)	
LA set	45 (8.88%)	329 (9.28%)	
RA lesion set	12 (2.37%)	44 (1.24%)	
Other	24 (4.73%)	110 (3.10%)	
Cox-Maze IV	110 (21.70%)	693 (19.54%)	
Energy source			<0.001
Cut-and-sew	32 (6.31%)	106 (2.99%)	
Unipolar RFA	22 (4.34%)	129 (3.64%)	
Bipolar RFA	157 (30.97%)	1,206 (34.03%)	
Cryoablation	211 (41.62%)	1,984 (55.98%)	
Microwave	2 (0.39%)	5 (0.14%)	
Laser	1 (0.20%)	5 (0.14%)	
Ultrasound	3 (0.59%)	47 (1.33%)	
Other	22 (4.24%)	56 (1.58%)	
Untreated arrhythmia	0 (0.0%)	17,532 (83.18%)	<0.001
LAA ligation	2, 768 (2.31%)	4,714 (22.37%)	<0.001
Untreated LAA	0 (0.0%)	16,363 (77.63%%)	<0.001
Complete AF surgery	0 (0.0%)	2,509 (11.90%)	<0.001

Abbreviations: AF, atrial fibrillation; LA, left atrium; PVI, pulmonary vein isolation; RA, right atrium; RFA, radiofrequency ablation; LAA, left atrial appendage.

surgery, AF was observed in approximately 13%–14% of cases. This is consistent with the contemporary literature [5,6]. AF was present in 23.24% of patients undergoing valve surgery. When considering all types of mitral valve surgery (isolated or concomitant), AF was found in 36.57% of cases, re-enforcing the strong association between mitral disease and AF. AF was closely linked to rheumatic disease, with 47% of patients with RHD having AF, as opposed to only 23.1% of patients with nonrheumatic valve disease (Table 3). Unsurprisingly, rheumatic disease was strongly associated with mitral valve disease: of the 3,703 patients with rheumatic disease, 3,701 had a mitral valve procedure. The combination of mitral valve disease and rheumatic disease was undoubtedly associated with higher rates of AF. Recent meta-analysis demonstrated that the global incidence of AF in RHD was 32.8%, which is markedly lower that the 47% incidence of AF in RHD in this cohort [20].

Concerningly, despite an incidence of AF of 14% across all cardiac operations, concomitant ablation and LAA ligation were performed in only 11.09% of patients with AF (Figure 1). Examining the change in practice since the change in guidelines in 2017, 11,760 patients with AF have undergone cardiac surgery, and only 1,467 (12.47% of patients with AF since the guideline change) have had combined ablation and LAA surgery, which is a slight increase from 11.18% of patients before 2017. There has been an increase in the utilisation of the CM IV procedure, considered the gold standard technique for surgical ablation, since the change in guidelines. This may be in part explained by changes in data collection and data definitions. The CM IV was performed in only 438 (41.44%) cases. In summary, among the 21,077 cases of AF over the last decade, only 438 (2.08% of the total AF group) had their AF treated according to best practice guidelines [5].

With respect to the utilisation of LAA ligation during concomitant surgery, it is difficult to analyse the true change in trends over time because of inherent coding limitations of the database. Namely, before 2016, LAA ligation was not recorded in the ANZSCTS database, and the records before this reflect ablative techniques that include LAA ligation as part of their technical description. Despite this, only 52.59% of patients with AF have had their LAA treated after the STS guideline change. While the utilisation of LAA ligation is far higher than that of AF ablative surgery, there are still 47.41% of patients with AF who have patent LAAs postoperatively. When examining the treatment trend more specifically in patients with mitral valve disease, the adoption of the STS guidelines appears to be more promising. Across the

Table 5 Mitral valve disease treatment patterns.

Variable	Yes	No	P-value
Mitral valve surgery with AF n=7,466			
LAA ligation	2,422 (32.44%)	5,044 (66.56%)	<0.001
Antiarrhythmic surgery	1,918 (25.69%)	5,548 (74.31%)	<0.001
Ablation+LAA ligation	1,472 (19.71%)	5,994 (80.29%)	<0.001
Complete or partial treatment of AF	2,868 (38.41%)	4,598 (61.59%)[a]	<0.001
Mitral valve surgery without AF n=12,948			
LAA ligation	1,159 (8.96%)	11,789 (91.04%)	<0.001
Antiarrhythmic surgery	233 (1.8%)	12,715 (98.2%)	<0.001
Ablation+LAA ligation	18 (0.14%)	12,930 (99.86%)	<0.001

[a]Represents patients with AF undergoing mitral valve surgery who did not receive any AF treatment, LAA ligation, or antiarrhythmic surgery.
Abbreviations: AF, atrial fibrillation; LAA, left atrial appendage.

examination period, the rates of treatment of AF during mitral valve surgery were higher than the rates observed across the cohort otherwise. Among the patients with AF and mitral valve disease, 19% have had complete AF treatment and 38% have had some attempt at AF surgery (either an ablation, ligation, or both). Ligation of the LAA is also consistently higher, with 32% of the patients with AF and mitral valve disease having had their appendage treated, as opposed to only 22% of the whole AF cohort in the last decade. The reasons for this are not explained by the data set. However, this may in part be due to heightened awareness of AF in mitral valve disease, access to the atria in mitral valve surgery allowing easy LAA closure (i.e., oversewing the LAA during the MVR), and ablation being performed while the atria are open and accessible, as opposed to remaining closed in procedures such as isolated coronary or aortic surgery. Concerningly, however, 61% of patients with mitral valve disease and AF had no form of AF treatment over the last 10 years.

The resistance to the adoption of ablative and LAA surgery found in this study, despite the change in recommendation for the use of these techniques, is complex and not explained fully by this data set. However, it is reassuring that there has been some increase in the utilisation of these techniques in patients with mitral valve disease considering the classification of these recommendations. Table 8 summarises the new findings from this review with respect to the current understanding of AF surgery.

Reflecting on the STS guidelines and the Class of Recommendation, there is significant discordance between Australian practice and international guidelines. Surgical ablation has a Class IB recommendation for patients with AF undergoing concomitant cardiac surgery, and a Class IA recommendation for those undergoing mitral valve surgery. A Class IA or IB recommendation indicates that there is robust evidence of the benefit outweighing the potential risk of the procedure, and consequently that the procedure should be considered for most patients [21]. In comparison, another Class IA recommendation, namely the use of the left internal mammary artery as a bypass graft for coronary disease in the left anterior descending artery during CABG, is applied in up to 92% of cases [22]. However, surgical ablation (of any kind) was performed in only 2.65% of appropriate patients following the introduction of these recommendations. Similarly, ligation of LAA (Class IIA recommendation) is reasonable to perform in most patients with AF undergoing cardiac surgery, as there is moderate evidence to suggest that its benefit outweighs potential harms. While there has been some increase in the utilisation of LAA ligation since the introduction of the STS guidelines, only 8.2% of patients who would potentially benefit from this procedure had it performed.

Understanding the barriers to the uptake of AF surgery in Australia and New Zealand is complex. To date, there is no current evidence to explain the reluctance of Australian and New Zealand surgeons to use these surgical techniques; while this registry review highlights the issue, it does not explain its causality. In contemporary studies in the United States, some factors identified as barriers to AF surgery include lack of awareness of the recommendations, insufficient education, and concerns around prolonging cardiopulmonary bypass and cross-clamp times and increased morbidity and mortality [23]. Explaining these complex and multifaceted barriers to AF surgery in Australia and New Zealand is beyond the scope and data set of this retrospective database analysis. However, in rebuttal to the argument that AF surgery is associated with increased morbidity and mortality, both the STS and the American Association for Thoracic Surgery (AATS) 2017 guidelines address this directly. Concomitant AF surgery does not affect operative mortality (Class IA, Level B, STS guidelines), but is rather associated with lower operative mortality (Class IA, Level A, AATS guidelines). Additionally, AF surgery does not affect operative morbidity (Class IA, Level B, STS guidelines). More research is required to understand the factors contributing to the reluctance of Australasian surgeons to treat AF surgically.

Limitations

This study is a retrospective review of a prospectively collected database, and thus has limitations inherent to this

Table 6 **AF surgery and adherence to guidelines.**

Variable	2012–2017	2017–2021	P-value
	n=65,276	n=75,404	
AF	9,317 (14.27%)	11,760 (15.60%)	<0.001
LAA ligation	1,298 (1.99%)	6,184 (8.20%)	<0.001
Untreated LAA	8,213 (12.58%)	8,150 (10.81%)	<0.001
Antiarrhythmic surgery	1,996 (3.06%)	2,000 (2.65%)	<0.001
Cox-Maze III	883 (42.97%)	344 (17.22%)	
Radial	21 (1.02%)	2 (0.10%)	
Mini-Maze	63 (3.07%)	85 (4.25%)	
LA reduction	101 (4.91%)	55 (2.75%)	
PVI	591 (28.76%)	541 (27.08%)	
LA set	220 (10.71%)	154 (7.71%)	
RA lesion set	22 (1.07%)	34 (1.70%)	
Other	81 (3.94%)	53 (2.65%)	
Cox-Maze IV	73 (3.55%)	730 (36.54%)	
Energy source			<0.001
Cut-and-sew	93 (4.53%)	45 (2.25%)	
Unipolar RFA	70 (3.41%)	81 (4.06%)	
Bipolar RFA	634 (30.85%)	729 (36.52%)	
Cryoablation	1,088 (52.94%)	1,107 (55.46%)	
Microwave	3 (0.15%)	4 (0.20%)	
Laser	4 (0.19%)	2 (0.01%)	
Ultrasound	50 (2.43%)	0 (0.0%)	
Other	50 (2.43%)	28 (1.40%)	
Untreated arrhythmia	7,535 (11.54%)	9,997 (13.26%)	<0.001
Complete AF surgery	1,042 (1.16%)	1,467 (1.95%)	<0.001
Ablation without AF	214 (0.33%)	237 (0.31%)	<0.001
LAA ligation without AF	194 (0.30%)	2,574 (3.41%)	0.65
Mitral valve disease and AF n=7,466	N=3,436	N=4,030	
LAA ligation	678 (19.73%)	1,744 (43.3%)	
AF ablation	970 (28.23%)	948 (23.52%)	
Untreated LAA	2,758 (82.6%)	2,286 (56.7%)	
Untreated arrhythmia	2,466 (71.77%)	3,082 (76.5%)	
LAA ligation+ablation	651 (18.95%)	821 (20.37%)	

Abbreviations: AF, atrial fibrillation; LAA, left atrial appendage; LA, left atrium; PVI, pulmonary vein isolation; RA, right atrium; RFA, radiofrequency ablation.

methodology. Importantly, in 2016, the definitions and data points recorded in the database changed from Version 3 to Version 4 of the Data Definitions Manual (Appendices 1 and 2). Importantly for this analysis, this change led to the creation of a separate data point for LAA closure and the inclusion of the CM IV. Before this, LAA ligation was not recorded in the data set. Building on this, LAA ligation before this time has been retrospectively coded on the basis of the ablation type performed and whether it includes LAA closure as part of the technical description (i.e., CM III). This change in data definitions and data points can partially explain the absence of the CM IV before 1 September 2016, despite being first described in 2002. Before the change, the utilisation of isolated LAA ligation or CM IV specifically is unclear, and the increase in utilisation of LAA ligation, noticed after 2017, may simply reflect the change in database variables. There may be AF operations being performed that are not captured in this data set. While all public cardiothoracic centres in Australia and one centre in New Zealand are captured in the ANZSCTS database, there are a number of private hospitals in Australia and hospitals in New Zealand that do not currently contribute to the database. This analysis does not consider the financial implications and remuneration/funding available for AF surgery and its changes over the last decade, as a confounder in this cohort.

Importantly, there are inherent limitations in the data set and collection, including the use of energy source for ablation. The ANZSCTS database only allows for coding of one energy source for ablation, and does not capture the fact that some clinicians use multiple energy sources/techniques to complete

Table 7 Ablation patterns and LAA ligation.

Variable	Without LAA ligation	LAA ligation	P-value
Antiarrhythmic surgery	n=1,228	n=2,825	<0.001
Cox-Maze III	0	1,227 (43.43%)	
Radial	19 (1.55%)	4 (0.14%)	
Mini-Maze	104 (8.47%)	44 (1.56%)	
LA reduction	133 (10.83%)	23 (0.83%)	
PVI	816 (66.45%)	316 (11.19%)	
LA lesion set	0	374 (13.24%)	
RA lesion set	49 (3.99%)	7 (0.25%)	
Other	107 (8.71%)	27 (0.96%)	
Cox-Maze IV	0	803 (28.42%)	

Abbreviations: LAA, left atrial appendage; LA, left atrium; PVI, pulmonary vein isolation; RA, right atrium.

surgical ablations. Additionally, while the data set is largely complete, the accuracy of the data must be considered. For example, there were 3,219 patients who received either an ablation or LAA ligation without documented AF in the data set. This may reflect inaccurate recording of AF, or reflect cases where these procedures were performed for indications other than the surgical management of AF.

Future Directions

Analysis of the ANZSCTS database may provide insights into the decision-making processes or predictors of not performing appropriate AF surgery. Examining the data set to understand the implications of AF surgery for morbidity and mortality may also be beneficial in understanding the contemporary practice and help shift it towards the current recommendations.

Recommendations

The long-term efficacy of LAA ligation in stroke prevention and surgical ablation in restoration of sinus rhythm is not captured by the current ANZSCTS database. Moving forward, the formulation and incorporation of a standardised care pathway after ablation/appendage procedures should be considered, specifically focusing on embolic stroke and arrhythmic burden. Complementary to this would be data linkage with the Australian Stroke Clinical Registry. Further research is needed to fully understand the reasons this surgery is underperformed, examining both patient and surgeon factors. Understanding the contemporary risks associated with incorporating these procedures into concurrent surgery may help shift the contemporary practice to align with the recommendations.

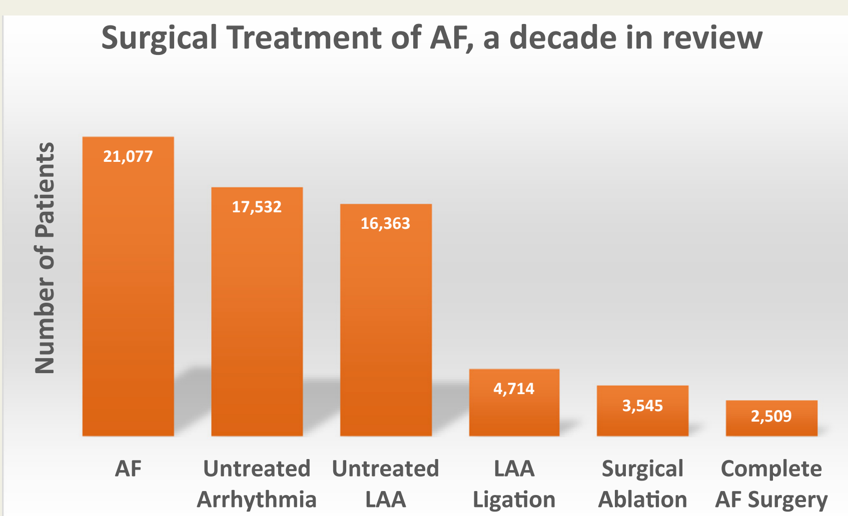

Figure 1 Surgical treatment of AF.
Abbreviations: AF, atrial fibrillation; LAA, left atrial appendage.

Table 8 Changes in our understanding of AF in Australian and New Zealand cardiac surgery.

Previous Understanding	Current Understanding
• Burden of AF : 5-11% • Treatment Pattern: ◦ LAA Ligation Rates: Unclear ◦ Ablation Rates: Unclear • Surgical Ablation ◦ Superior in restoring sinus rhythm compared to any other treatment • Surgical Ablation does not increase operative mortality or morbidity • Surgical Ablation of AF during cardiac surgery provides significant prognostic benefit ◦ 62% survival vs 42% at 10 years • LAA ligation significantly reduces embolic stroke risk (independent of anti-coagulation) Treatment Guidelines for AF • Surgical Ablation during cardiac surgery is a Class IA recommendation in mitral surgery and IB in all other surgery • LAA Ligation during cardiac surgery is a Class IIA recommendation	• Burden of AF: ◦ 14% or ◦ 21,077 of 140,680 patients having surgery • Treatment ◦ LAA Ligation: ∼22% of those with an indication in the last decade had their appendage addressed ◦ Ablation Rates: 16.8% of patients with AF have received an ablation in the last decade

Abbreviations: AF, atrial fibrillation; LAA, left atrial appendage.

Conclusion

The burden of AF in patients undergoing cardiac surgery in Australia and New Zealand is higher than expected in the literature. Despite this higher incidence, the surgical management of AF in Australia and New Zealand has been substantially underutilised over the last decade. The contemporary practice of cardiac surgery and concomitant AF surgery does not reflect the current surgical guidelines. Further research is required to understand why AF surgery is underperformed in Australia and New Zealand.

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Study Approvals

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Appendices

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hlc.2024.07.007.

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