Predictors of atrial fibrillation post coronary artery bypass graft surgery: new scoring system

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ABSTRACT

Background Atrial fibrillation (AF) following coronary artery bypass graft surgery (CABG) is common and results in significant increases in hospital stay and financial encumbrance.

Objective Determine and use the predictors of postoperative AF (POAF) following CABG to develop a new predictive screening tool.

Method A retrospective case–control study evaluated 388 patients (98 developed POAF and 290 remained in sinus rhythm) who undertook CABG surgery at Townsville University Hospital between 2016 and 2017. The demographic profile, risk factors for AF including hypertension, age ≥ 75 years, transient ischaemic attack or stroke, chronic obstructive pulmonary disease (HATCH) score, electrocardiography features and perioperative factors were determined.

Results Patients who developed POAF were significantly older. On univariate analysis HATCH score, aortic regurgitation, increased p-wave duration and amplitude in lead II and terminal p-wave amplitude in lead V1 were associated with POAF, as were increased cardiopulmonary bypass time (103.5 ± 33.9 vs 90.6 ± 26.4 min, p = 0.001) and increased cross clamp time. On multivariate analysis age (p = 0.038), p-wave duration > 100 ms (p = 0.005), HATCH score (p = 0.049) and CPB Time > 100 min (p = 0.001) were associated with POAF. Receiver operating characteristic curve demonstrated that with a cut-off of ≥ 2 for HATCH score, POAF could be predicted with a sensitivity of 72.8% and a specificity of 34.7%. Adding p-wave duration in lead II > 100 ms and cardiopulmonary bypass time > 100 min to the HATCH score increased the sensitivity to 83.7% with a specificity of 33.1%. This was termed the HATCH-PC score.

Conclusion Patients with HATCH scores ≥ 2, and those with p-wave duration > 100 ms, or cardiopulmonary bypass time > 100 min were at greater risk of developing POAF following CABG.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Atrial fibrillation is a common complication following coronary artery bypass graft (CABG) surgery, which is associated with significant increases in cost, morbidity and mortality. Many predictors of postoperative atrial fibrillation (POAF) have been identified, including hypertension, age ≥ 75 years, transient ischaemic attack or stroke, chronic obstructive pulmonary disease (HATCH) score, electrocardiography features and perioperative factors were determined.

WHAT THIS STUDY ADDS

⇒ By adding two additional variables to the HATCH score, including p-wave duration > 100 ms and cardiopulmonary bypass time > 100 min, the HATCH-PC method is a more sensitive tool in predicting POAF following CABG.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ To date, no studies have combined prophylactic therapies in conjunction with a risk stratification model. Future research should be conducted investigating the use of prophylactic therapies in combination with risk stratification of POAF. To facilitate this, a prospective observation study is required to validate a risk stratification tool such as HATCH-PC.

INTRODUCTION

Atrial fibrillation (AF) is a common complication following coronary artery bypass grafting (CABG) surgery. Postoperative AF (POAF) most commonly develops on day 2 or 3 postoperatively, and affects 20%–40% of patients following CABG.1 Acutely, POAF is associated with increased intensive care and in-hospital stays, and higher readmission rates.1–4 The financial costs associated with POAF are estimated at US$10 000–US$11 500 per patient.5 Thus, POAF has important economic and public health effects, especially with regards to human resources and delaying bed turnover. Additionally, POAF is associated with higher rates of postoperative renal insufficiency, infection, ventricular arrhythmia and stroke.1,2 Over the long-term POAF is associated with higher rates of permanent AF and stroke.5,6 Studies have demonstrated that the 30-day mortality rate and long-term mortality rate at 15 years to be significantly higher in patients who develop POAF following CABG.2,7
Our study aims to identify risk factors associated with the development of POAF following CABG, and develop a screening tool to help identify patients at high risk of developing POAF. Such identification may allow for more targeted postoperative surveillance and monitoring, and potentially enable targeted prophylactic treatment for high-risk individuals.

**METHOD**

**Study population**
POAF was defined as any episode of AF that failed to terminate spontaneously after 5 min, or required pharmacological or electrical cardioversion.

**Inclusion criteria**
Patients who were over 18 years old and underwent CABG at Townsville University Hospital, a tertiary hospital, between 1 January 2016 and 31 December 2017 were eligible for inclusion, amounting to 498 patients.

**Exclusion criteria**
Patients were excluded from the study if they had a history of AF. Patients undertaking CABG along with valvular replacement in the same operation were excluded. Patients who died acutely in the perioperative setting were excluded as no postoperative ECG data were available. Following the application of exclusion criteria, a total of 388 people were included.

**Sample size**
Using Open Epi V.3, a sample size of 193 people was calculated. The prevalence of POAF following CABG was assumed to be 20% with 95% confidence based on the existing literature. Type I error was set at 0.05 and power at 0.90.

**Demographic factors**
Age, gender, weight, height and body mass index along with concurrent comorbidities including hypertension, diabetes, history of stroke or trans-ischaemic attack, cardiac failure, peripheral arterial disease and smoking status were assessed. Using these data, the hypertension, age≥75 years, transient ischaemic attack or stroke, chronic obstructive pulmonary disease, and heart failure (HATCH) score was calculated for each patient (2 points for either a history of transient ischaemic attack/stroke or heart failure, respectively; 1 point for hypertension, age >75 years or chronic obstructive pulmonary disease (COPD), respectively).

**ECG parameters**
Standard 12-lead ECG acquired at paper speed of 25 mm/s and standard calibration 10 mm/mV, was used for analysis. ECG parameters were obtained from preoperative ECGs and included p-wave duration (ms) and amplitude (mV) measured in Lead II along with the negative deflection of the p-wave in V1 duration (ms) and amplitude (mV) below isoelectric baseline. The terminal p-wave force, that is, the area of negative p-wave deflection in V1, was calculated by multiplying the negative deflections duration and amplitude.

**Echocardiogram**
Preoperative transthoracic echocardiogram results for left ventricular ejection fraction (LVEF), and the presence of valvular pathology were included.

**Perioperative factors**
Cardiopulmonary bypass (CPB) time, cross clamp time, number of diseased coronary arteries and haemoglobin levels at the time of CPB were included. Postoperative factors such as intercostal catheter loss in the first 4 hours postoperatively was measured in mL and intensive care unit (ICU) length of stay measured in hours and minutes were also noted.

A retrospective case–control study design was used. All data were gathered by the same assessor to maintain continuity. Twenty-seven ECGs (approximately 1 in 15 patients) were selected and measured by a second independent blind assessor for intraclass correlation.

**Statistical analysis**
IBM SPSS statistics software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, V.25.0., IBM) was used for statistical analysis.

Most continuous data were non-parametric, hence were expressed as medians and IQRs. Exceptions included cross clamp time, CPB time and haemoglobin levels at time of CPB, which were parametric and were expressed as mean±SD. Univariate analysis was performed using Student’s t-test and Mann-Whitney U test for parametric and non-parametric data, respectively. χ² test was used to compare categorical variables. Variables were included for multivariate analysis if p<0.1 on univariate analysis. OR, p<0.05 and 95% CIs were obtained for variables included in multivariate analysis to determine independent predictors of POAF. Receiver operating characteristics curve analysis was performed to assess sensitivity and specificity of various models. The intraclass correlation assessed p-wave length in lead 2, and assumed a two-way mixed model, with absolute agreement, and CIs of 95%. A p<0.05 was considered statistically significant for the study.

**RESULTS**

**Study population**
Of the 498 patients who underwent CABG, 388 patients met inclusion criteria (table 1). A majority of the 388 patients were elderly males (78.4%) with a median age of 62 (54–75 years). The two most common comorbidities in this population were a history of smoking (71.9%) and hypertension (79.1%).

Of the 388 patients, 98 (25.3%) developed POAF. Importantly, POAF was associated with increased ICU length of stay (43 hours:31 min vs 27 hours:54 min p<0.05). The preoperative baseline characteristics, echocardiogram and ECG findings of the POAF group and sinus rhythm (SR) group are shown in tables 2 and 3. The
Cardiac surgery

The POAF group had a significantly older population with a median age of 65 (IQR: 12.5) vs 61 (IQR: 16), p<0.001. Both groups had similar anthropometrics and comorbidity risk.

The development of POAF was associated with higher HATCH scores, p=0.019. However, the median and IQR were the same for both the POAF and SR group, while the mean score in the POAF group was greater than the SR group (1.5±SD=1.018 vs 1.21±SD=1.16).

Increased p-wave duration (ms) and amplitude (mV) in lead II on preoperative ECGs were associated with the POAF group. The intraclass correlation for p-wave duration in lead II was 0.725 (95% CI 0.046 to 0.9, p<0.001), with a Cronbach’s alpha of 0.832. In V1 having a deeper terminal p-wave depth (mV) was associated with the POAF group, while terminal p-wave duration (ms) and force (ms×mV) was not associated.

Aortic regurgitation was the only echocardiography risk factor to reach significance with an OR of 2.318 (1.027–5.234).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>304 (78.4%)</td>
</tr>
<tr>
<td>Age</td>
<td>62 (54–75)*</td>
</tr>
<tr>
<td>BMI</td>
<td>28.37 (24.37–32.16)*</td>
</tr>
<tr>
<td>Current smoking status (n=358)</td>
<td>124 (34.6%)</td>
</tr>
<tr>
<td>History of smoking (n=370)</td>
<td>277 (74.9%)</td>
</tr>
<tr>
<td>HTN</td>
<td>307 (79.1%)</td>
</tr>
<tr>
<td>Age &gt;75</td>
<td>37 (9.5%)</td>
</tr>
<tr>
<td>TIA/stroke</td>
<td>4 (1.0%)</td>
</tr>
<tr>
<td>COPD</td>
<td>67 (17.3%)</td>
</tr>
<tr>
<td>CCF (EF&lt;40%)</td>
<td>40 (10.3%)</td>
</tr>
<tr>
<td>PAD</td>
<td>31 (8.0%)</td>
</tr>
</tbody>
</table>

Values are presented as n (%).

Table 2 Differences between patients with POAF and sinus rhythm (n=388)

<table>
<thead>
<tr>
<th>Variable</th>
<th>POAF n=98 (25.3%)</th>
<th>Sinus rhythm n=290 (74.7%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at operation</td>
<td>65 (58–71)</td>
<td>61 (53–69)</td>
<td>0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170 (166–176)</td>
<td>171 (165–177)</td>
<td>0.640</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>85 (98–73)</td>
<td>83 (73–95)</td>
<td>0.792</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>29.07 (24.75–32.30)</td>
<td>28.37 (24.98–32.32)</td>
<td>0.582</td>
</tr>
<tr>
<td>ECG changes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-wave duration in lead II (ms)</td>
<td>100 (86.67–113.33)</td>
<td>93.33 (80–100)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>p-wave amplitude in lead II (mV)</td>
<td>0.1 (0.067–0.1167)</td>
<td>0.1 (0.05–0.1)</td>
<td>0.017</td>
</tr>
<tr>
<td>Terminal p-wave duration (ms)</td>
<td>40 (30–60)</td>
<td>40 (40–60)</td>
<td>0.336</td>
</tr>
<tr>
<td>Terminal p-wave depth (mV)</td>
<td>0.05 (0.05–0.1)</td>
<td>0.05 (0.025–0.05)</td>
<td>0.046</td>
</tr>
<tr>
<td>Terminal p-wave force (ms x mV)</td>
<td>2 (1–4)</td>
<td>2 (1–4)</td>
<td>0.259</td>
</tr>
<tr>
<td>Preoperative risk factors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HATCH Score</td>
<td>1 (1-2)</td>
<td>1 (1-2)</td>
<td>0.019</td>
</tr>
<tr>
<td>LV ejection fraction</td>
<td>59 (46–61)</td>
<td>55 (50–60)</td>
<td>0.981</td>
</tr>
<tr>
<td>Intraoperative risk factors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiopulmonary bypass time total (min)</td>
<td>103.51±33.927</td>
<td>90.64±26.393</td>
<td>0.001</td>
</tr>
<tr>
<td>Cross clamp time total (min)</td>
<td>71.98±28.413</td>
<td>63.22±23.529</td>
<td>0.009</td>
</tr>
<tr>
<td>Haemoglobin (g/L)</td>
<td>91.93±17.638</td>
<td>91.08±17.898</td>
<td>0.691*</td>
</tr>
<tr>
<td>Postoperative variables:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercostal catheter loss at 4 hours postoperative (mL)</td>
<td>320 (169–510)</td>
<td>250 (160–400)</td>
<td>0.093</td>
</tr>
<tr>
<td>ICU Length of stay (hour:min)</td>
<td>43:49 (25:05–69:33)</td>
<td>28:00 (23:05–50:31)</td>
<td>0.024</td>
</tr>
</tbody>
</table>

Values expressed as mean±SD or median (IQR).

Increased mean CPB time (103.5±33.9 vs 90.6±26.4 min, p=0.001) and mean cross clamp time (72.0±28.4 vs 63.2±23.5 min, p=0.009) were both associated with the POAF group. A CPB time of more than 100 min was associated with a two-fold increased risk of POAF (OR 2.205, 95% CI 1.382 to 3.519, p=0.001).

Our multivariate analysis demonstrated in table 4 had a presentation accuracy in classification of 77.9%. Furthermore, our model shows advanced age to be the most important risk factor for the development of POAF, with p-wave duration in Lead II, HATCH score and CPB time also being significantly, and therefore, independently associated with the development of POAF. The presence of aortic regurgitation on echocardiography failed to reach significance in multivariate analysis.

A HATCH score of ≥2 was associated with a 34.7% sensitivity (Sn) and a 72.8% specificity (Sp) for predicting POAF. Sensitivity was improved while specificity declined when p-wave ≥100 ms (Sn=65.3%, Sp=47.6) and CPB ≥100 min (Sn=83.7%, Sp=33.1%) were added successively, as demonstrated in figure 1. In both situations a score of 1 point was added to the patients’ underlying HATCH score for each positive variable, this was termed HATCH-PC. Furthermore, higher scores were associated with improved specificity and reduced sensitivity across all models. In this population where the prevalence of POAF was 25.3% the HATCH-PC model had a negative predictive value (NPV) of 85.71%.

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>1.104</td>
<td>0.628 to 1.942</td>
<td>0.730</td>
</tr>
<tr>
<td>Age categorised in 15 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>1</td>
<td></td>
<td>0.010</td>
</tr>
<tr>
<td>50–64</td>
<td>3.756</td>
<td>1.277 to 11.044</td>
<td>0.016</td>
</tr>
<tr>
<td>65–79</td>
<td>5.714</td>
<td>1.952 to 16.729</td>
<td>0.001</td>
</tr>
<tr>
<td>80+</td>
<td>6.000</td>
<td>1.074 to 33.53</td>
<td>0.041</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Comorbidities:</th>
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<tbody>
<tr>
<td>Hypertension</td>
<td>1.481</td>
</tr>
<tr>
<td>Age &gt;75</td>
<td>1.695</td>
</tr>
<tr>
<td>TIA/stroke</td>
<td>9.126</td>
</tr>
<tr>
<td>COPD</td>
<td>1.107</td>
</tr>
<tr>
<td>Heart failure (EF&lt;40%)</td>
<td>1.692</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>1.232</td>
</tr>
<tr>
<td>Current smoking</td>
<td>0.827</td>
</tr>
<tr>
<td>Smoking history</td>
<td>0.698</td>
</tr>
<tr>
<td>Statin therapy</td>
<td>1.429</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.267</td>
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<table>
<thead>
<tr>
<th>Perioperative risk factors:</th>
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<tbody>
<tr>
<td>Left main coronary artery stenosis</td>
<td>1.066</td>
</tr>
<tr>
<td>Cardiopulmonary bypass</td>
<td>1.197</td>
</tr>
<tr>
<td>p-wave duration 100 ms</td>
<td>2.084</td>
</tr>
<tr>
<td>Cardiopulmonary bypass ≥100 min</td>
<td>2.205</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Echocardiogram results:</th>
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</thead>
<tbody>
<tr>
<td>Mitral regurgitation</td>
<td>1.485</td>
</tr>
<tr>
<td>Tricuspid regurgitation</td>
<td>1.994</td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td>1.485</td>
</tr>
<tr>
<td>Aortic regurgitation</td>
<td>2.318</td>
</tr>
</tbody>
</table>

All values represent Pearson’s χ² with continuity correction.
Other abbreviations as in table 1.
*Fisher’s exact test due to violation of Pearson’s χ² test assumptions.
COPD, chronic obstructive pulmonary disease; EF, ejection fraction; POAF, postoperative atrial fibrillation; TIA, transient ischaemic attack.
DISCUSSION

The prevalence of new-onset POAF following CABG was 25.3% at Townsville University Hospital between 2016 and 2017, which compares with other international studies.\(^1\) Independent risk factors for the development of POAF included age, p-wave duration in lead II, HATCH score and CPB time.

Patient age was the most significant risk factor and is a well-documented association.\(^1\) Mathew et al estimated that for every 10 years of age, the risk of POAF increased by 75%.\(^1\) Our model assessed the OR at 15-year increments from 50 years old and found a similar positive association with the development of POAF. It should be noted however, that Mathew et al’s study included patients undertaking valve replacement, which itself is associated with higher rates of POAF, therefore, making direct comparison difficult.\(^1\) Physiologically, it has been postulated that age-associated anatomical remodelling and fibrosis of the conduction pathways may predispose to the development of POAF.\(^12\)

Furthermore, it has been hypothesised that preoperative ECGs may detect underlying atrial conductive abnormalities, particularly those associated with left atrial dilatation.\(^13\) Increased p-wave amplitude and duration in lead 2, and the p-wave negative deflection characteristics of terminal p-wave duration (ms), depth (mV) and force (ms×mV) in precordial lead V1 has previously been correlated with increased left atrial size.\(^9\) A 2018 metaanalysis and prospective cohort study by Wu et al found similar results to our study with pre-operative p-wave duration >105 ms being strongly associated with increased risk of POAF, OR 4.63, 95% CI 2.66 to 8.03 p<0.001.\(^14\) Moreover, a majority of the literature surrounding pre-operative p-wave duration is more than 15 years old, and while their results support our study’s findings, more up-to-date literature is needed to reflect the change in clinical and

### Table 4  Multiple logistic regression analysis—risk factors for the development of POAF (n=388)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multivariate</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age categorised in 15 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>50–64</td>
<td>3.938</td>
<td>0.015</td>
</tr>
<tr>
<td>65–79</td>
<td>4.989</td>
<td>0.004</td>
</tr>
<tr>
<td>80+</td>
<td>6.138</td>
<td>0.050</td>
</tr>
<tr>
<td>p-wave duration ≥100 ms</td>
<td>2.027</td>
<td>0.005</td>
</tr>
<tr>
<td>HATCH score</td>
<td>1.301</td>
<td>0.049</td>
</tr>
<tr>
<td>Cardiopulmonary bypass time ≥100 min</td>
<td>2.218</td>
<td>0.001</td>
</tr>
<tr>
<td>Aortic regurgitation</td>
<td>1.605</td>
<td>0.295</td>
</tr>
</tbody>
</table>

Other abbreviations as per table 2. HATCH, hypertension, age≥75 years, transient ischaemic attack or stroke, chronic obstructive pulmonary disease and heart failure; POAF, postoperative atrial fibrillation.

**Figure 1**  Receiver operating characteristics curve (ROC) of HATCH score plus add on scoring methods with 1 point allocated for having either p-wave ≥100 ms or CPB ≥100 min for predicting atrial fibrillation after coronary artery bypass graft surgery. AUC, area under the curve; CPB, cardiopulmonary bypass; HATCH, hypertension, age ≥75 years, transient ischaemic attack or stroke, chronic obstructive pulmonary disease and heart failure.
With an intraclass correlation value of 0.725, measuring p-wave duration in lead II is moderately reliable.17

The surgical factors of CPB time and cross clamp time were both associated with increased rates of POAF. The ischaemic reperfusion injury associated with cross clamp release, and the proinflammatory state triggered by complement system activation associated with CPB use have both been proposed as possible triggers for the development of POAF.18 19 Importantly, when CPB time exceeded 100 min the patients’ risk of developing POAF doubled. Similarly, the POAF group had significantly longer CPB times, p=0.041, in Tsai et al’s 2015 study on isolated CABG patients.11 However, Hashemzadeh et al in a multivariate analysis found increased CPB time was associated with lower rates of POAF (OR 0.984 (95% CI 0.976 to 0.992) p<0.001).20

The presence of aortic regurgitation was associated with POAF on univariate analysis, but failed to demonstrate an independent association on multivariate analysis. However, since patients undergoing concurrent valve replacement were excluded from the study, severe valvular disease was unlikely to be seen, hence only the presence of valvular pathology was included rather than disease severity. Aksu et al and Abdel-Salam and Nammas supported these findings, finding no association between valvular pathology or LVEF and POAF following CABG.21 22 Furthermore, no studies could be found assessing tricuspid regurgitation and POAF, making our study potentially the first to assess this variable despite its non-significant finding.

The study population had well-preserved left ventricular function with only 10.3% of the total population having an ejection fraction of <40%, while the median LVEF were 59% (IQR 46–61) in the POAF group and 55% (50–60) in the SR group. A meta-analysis by Yamashita et al found both reduced LVEF and history of heart failure (LVEF<40%) to be associated with the development of POAF across 7 and 4 studies, respectively. Yamashita et al did highlight significant heterogeneity between data sets especially with respect to LVEF which had an I² of 0.79.23

The studies investigating the relationship between the HATCH score and POAF are limited.10 24 25 Selvi et al and Emren et al had a similar study design being retrospective studies assessing POAF following CABG. Burgos et al have produced two papers the first from 2019 which focused on all cardiac surgeries of which only 2% of patients had an isolated CABG; compared with 31% having isolated CABG in their 2021 paper, making comparison difficult.10 24–26 In our study for every 1 point increase in the HATCH score, the risk of POAF increased by 1.312 times. This was comparable to Selvi et al who found an adjusted OR of 1.334 (95% CI 1.022 to 1.741) p=0.034.10 Similarly, Burgos et al’s 2021 paper who found an adjusted OR of 1.18 (95% CI 1.018 to 1.36) p=0.04, while Emren et al found a statistically significant relationship in univariate analysis, but failed to perform a multivariate analysis.24 26

Both Selvi et al and Emren used receiver operator curves to validate the potential use of the HATCH score as a predictive test for POAF. Both studies also used a HATCH score of ≥2. Selvi et al found similar results with a sensitivity of 42% and specificity of 70%. These are comparable to our findings of 34.7% sensitivity and 72.8% specificity. Emren et al on the other hand, found a sensitivity of 77% and specificity of 62%. Furthermore, Emren et al found a statistically significant relationship between POAF and COPD and lower ejection fraction (<40%), a relationship not supported by either Selvi et al, or the findings of our study.10 24 Our results suggest that by including CPB time ≥100 min and p-wave duration (≥100 ms) in addition to the HATCH score, proved to be more sensitive screening test than HATCH alone. While difficult to directly compare; the HATCH-PC model, which exclusively assesses patients for risk of POAF following CABG, demonstrated higher sensitivity but lower specificity compared with the COM-AF model, a recent model proposed in Burgos et al’s 2021 paper for predicting POAF in all postoperative cardiac patients.26

Clinical implications

The financial costs associated with POAF are estimated at US$10 000–US$11 500 per patient, with increased ICU length of stay being a contributor.3 In our study the development of POAF increased median ICU length of stay by 16 hours, costing approximately $A3276 (US$2286) per patient with POAF, based on the 2019 Independent Hospital Pricing Authority estimate of average ICU cost in Australia, and a $1AUD to $0.70USD exchange rate.27 28

While this is a crude measure of the economic burden, it clearly demonstrates the financial implications of POAF and value in findings measures to reduce its prevalence.

Several prophylactic interventions for POAF have been investigated, however, inconsistent results have limited their adoption. Treatments such as amiodarone and beta-blockers in the early postoperative period have been trialled, but limited by inconsistent evidence and fears that such interventions may cause more harm than good.29 30 Offering therapy only to high-risk individuals has the potential to reduce adverse effects on a population level with less patients unnecessarily exposed, while providing an intervention with a potential benefit to those most in need. To date, no studies have combined prophylactic therapies in conjunction with a risk stratification model—that is, providing targeted prophylactic intervention. Hence, the utility of the HATCH or HATCH-PC model in combination with prophylactic therapy is an area where future research is required in the form of prospective clinical trials.

Limitations

This study relied on well-documented and accurate medical records, with a major limitation being the availability and reliability of the data. To overcome this challenge, data were assessed from various sections of the medical charts including preoperative surgical notes,
ECG data records and discharge letters. An example of information not found was left atrial size, a known risk factor for POAF, instead indirect measures such as p-wave length and amplitude were used. Furthermore, trouble and standards of data collection were maintained by only having one team member performing the data collection. An example where observer measurement error may have taken place includes the measurements of p-waves, where the small measurement values on a standardly calibrated ECG, may have predisposed to error. Furthermore, the wide CI and low number of participants with stroke suggest that this study is likely too underpowered to draw meaningful conclusions regarding this risk factor. Two additional limitations of this study are the single-centre experience and retrospective design meaning that the findings of the study only show an association between the HATCH-PC model and predicting POAF in patients post-CABG. Furthermore this study does not demonstrate that the HATCH-PC model improves outcomes, formal prospective trials would be required to confirm its clinical utility.

**Strengths**

This is the largest study to date that has evaluated the HATCH scoring method in relation to POAF in an isolated CABG population, and the first that has combined the HATCH scoring method with additional risk factors to help improve its sensitivity and clinical utility. The addition of p-wave duration and CPB time to the HATCH score provides a scoring system that is easy to calculate and does not require invasive laboratory tests to improve sensitivity, and identify people who are at increased risk of developing POAF following CABG. This information could be used to improve monitoring or commence prophylactic interventions on patients who are identified as being at higher risk.

**CONCLUSION**

Overall, patients with a higher HATCH score may be at greater risk of developing POAF following CABG. However, with low sensitivity, our study does not support the use of the HATCH score as a screening tool for predicting POAF. Furthermore, our results would suggest that by adding two additional variables to the HATCH score, including p-wave duration ≥100 ms and CPB time ≥100 min, the HATCH-PC method is a more sensitive tool in predicting POAF following CABG. Future research should be conducted investigating the use of prophylactic therapies in combination with risk stratification of POAF.

**Contributors**

KL: data collection, statistical analysis, lead author, guarantor. SY: manuscript and editing. PS: manuscript and editing. VV: statistical analysis support and project supervision. BJ: team leader, supervisor and corresponding author.

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**Competing interests**

None declared.

**Patient consent for publication**

Not applicable.

**Ethics approval**

Ethics and site-specific approval were granted by the Townsville District Human Research Ethics Committee and the Townsville Hospital and Health Service Research Governance Office, HREC/18/THS/155. The study was in accordance with the Queensland Government Public Health Act and undertaken as part of the research collaboration between Townsville Hospital and Health Service and James Cook University. A deidentified patient list was provided by Queensland State-wide Cardiac Clinical Informatics Unit. All data were gathered retrospectively using the ‘eMR’ electronic record system.

**Provenance and peer review**

Not commissioned; externally peer reviewed.

**Data availability statement**

All data relevant to the study are included in the article or uploaded as online supplemental information.

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