Left Atrial Appendage Emptying Velocity Does Not Predict Postoperative Atrial Fibrillation in Patients Undergoing Cardiopulmonary Bypass

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Background: Atrial fibrillation is a common complication of cardio-pulmonary bypass and improved pre-operative risk assessment could help guide prophylactic therapy. This study examined whether reduced left atrial appendage flow velocities measured by transoesophageal echocardiography pre-operatively in patients in sinus rhythm predicted development of postoperative atrial fibrillation.

Methods and Results: All patients who underwent transoesophageal echocardiography for clinical indications with measurements of left atrial appendage velocities within twelve months prior to cardio-pulmonary bypass were retrospectively identified. Postoperative records were reviewed and the patients divided into two groups based on the presence or absence of clinically significant atrial fibrillation during hospitalization following cardio-pulmonary bypass. Thirty-six patients (mean age 61±14.8 years, 18M/18F) were included in the study. The overall incidence of atrial fibrillation in the cohort was 17/36 patients (47%). Mean left atrial appendage emptying velocity was 50.8±23.3 cm/s² (range 26–119) in the patients with sinus rhythm only and 41.5±16.7 cm/s² (range 16–76), in the patients with postoperative atrial fibrillation (P=ns).

Conclusions: In our patient population there was no significant difference in left atrial appendage emptying velocity measured by transoesophageal echocardiography in patients with and without postoperative atrial fibrillation. Pre-operative measurement of left atrial appendage emptying velocity cannot be relied upon to risk stratify patients prior to cardio-pulmonary bypass.

Key Words: atrial fibrillation; cardiopulmonary bypass; left atrium; transoesophageal echocardiography

Introduction

Atrial fibrillation is a common complication of cardio-pulmonary bypass surgery occurring in 30–50% of such patients[1–3]. Although generally not life-threatening, this complication may result in significant morbidity and increased length-of-stay and cost[4,5]. Prophylactic medical and mechanical strategies have been investigated but are costly, of limited effectiveness and expose large numbers of patients who would be free of arrhythmia to potential side effects[6–9]. Numerous studies have attempted to identify predictors of postoperative atrial fibrillation which have included age, valvular heart disease, withdrawal of beta-blocking therapy, right coronary artery grafting and signal averaged p-wave duration[10–14]. More effective risk stratification pre-operatively would direct prophylactic strategies toward a high-risk group, presumably maximizing effectiveness while minimizing the number needed to treat.

Transoesophageal echocardiography is commonly performed in patients prior to cardio-pulmonary bypass for a variety of clinical indications. Because of the posterior location of the transducer transoesophageal echocardiography provides excellent visualization of the left atrial appendage and left atrial appendage function can be easily assessed using Doppler techniques[15]. As development of postoperative atrial fibrillation may be related in part to left atrial dysfunction prior to surgery, assessment of left atrial appendage function by transoesophageal echocardiography may be predictive of this complication[16,17]. To our knowledge no previous study has examined this question. Therefore, this study was undertaken to investigate the ability of transoesophageal
echocardiography evaluation of left atrial appendage function to predict postoperative atrial fibrillation.

**Methods**

**Study Population**

All patients who underwent transoesophageal echocardiography for clinical indications within 12 months prior to cardio-pulmonary bypass and who were in normal sinus rhythm at the time of surgery were retrospectively identified from the hospital computer database. Patients with permanent pacemakers, a history of paroxysmal atrial arrhythmias or who were receiving antiarrhythmic therapy at the time of surgery were excluded from the study. Only patients who survived to hospital discharge were included in the study. Cardio-pulmonary bypass was performed in standard fashion and all patients were monitored in intensive care for at least 24 h following the procedure. Clinical data including presence of postoperative arrhythmias were retrieved by chart review including ECG monitoring records. Clinically significant atrial fibrillation was defined as atrial fibrillation requiring medical therapy which was either aimed at rate control, rhythm control or both.

**Transoesophageal Echocardiography**

Transoesophageal echocardiography studies were performed using 5 or 7 mHz omniplane probes after oropharyngeal anaesthesia and light sedation with midazolam. Once adequate two-dimensional images of the left atrial appendage were obtained, a pulse-wave Doppler sample volume was placed in the body of the left atrial appendage and Doppler velocities were recorded. Three consecutive peak emptying velocities were averaged to determine mean left atrial appendage emptying velocity. Measurements of left atrial size were performed offline from two-dimensional images in the four-chamber view.

**Statistical Analysis**

For purposes of analysis patients were divided into two groups based on the presence or absence of clinically significant (requiring medical therapy) atrial fibrillation during hospitalization following cardio-pulmonary bypass. Comparisons between groups were performed using unpaired t-test or Mann-Whitney U test for continuous variables; Fisher exact test or chi-square test for categorical variables. A P value of <0.05 was considered statistically significant.

**Results**

A total of 36 patients met the entry criteria and were entered into the study. Clinical characteristics of the study population are presented in Table 1. There were no significant differences in baseline demographics between the two groups. Clinical indications for transoesophageal echocardiography included assessment of mitral valve anatomy in 23 patients, evaluation of the ascending aorta in 10, assessment of the aortic valve in four, rule out vegetation in two, source of embolus in two, and evaluation of left atrial myxoma in one. (Some patients had more than one indication for transoesophageal echocardiography.) The overall incidence of clinically significant atrial fibrillation in the cohort was relatively high at 47%. Mean left atrial diameter was 47.1 ± 8.1 mm in the sinus rhythm group and 50.5 ± 5.8 mm in the atrial fibrillation group (P=ns).

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**Table 1. Clinical characteristics of the study population (n=36).**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Sinus rhythm</th>
<th>Atrial fibrillation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>59.2 ± 17.4</td>
<td>63.0 ± 12.1</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>9/10</td>
<td>9/8</td>
</tr>
<tr>
<td>Mean time between TEE and CPB (days)</td>
<td>73.7 ± 110.0</td>
<td>59.9 ± 64.8</td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVR</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>CABG</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>CABG+AVR</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>MVR/AVR</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CABG+MVR</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AAA</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>AVR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mean LAA velocities (cm/s²)</td>
<td>50.8 ± 23.3</td>
<td>41.5 ± 16.7</td>
</tr>
<tr>
<td>range</td>
<td>26–119</td>
<td>16–76</td>
</tr>
</tbody>
</table>

TEE = transesophageal echocardiography; CPB = cardiopulmonary bypass; MVR = mitral valve replacement/repair; CABG = coronary artery bypass surgery; AVR = aortic valve replacement; AAA = ascending aortic aneurysm; LAA = left atrial appendage; ns = not significant.
Mean left atrial appendage emptying velocity was 50·8 ± 23·3 cm/s\(^2\) in the patients who remained in sinus rhythm and 41·5 ± 16·6 cm/s\(^2\) in the patients who developed post-operative atrial fibrillation (P = ns). The range of values for left atrial appendage emptying velocity was 26–119 cm/s\(^2\) in the sinus rhythm group and 16–76 cm/s\(^2\) in the atrial fibrillation group. There was no threshold of left atrial appendage emptying velocity below which atrial fibrillation consistently occurred. Mean left atrial appendage area was 5·5 ± 2·9 cm in the atrial fibrillation group and 4·7 ± 1·7 cm in the sinus rhythm group (P = ns). Two patients had mild spontaneous echo contrast noted on transoesophageal echocardiography, both of whom suffered from mitral stenosis. One of these patients developed atrial fibrillation postoperatively.

**Discussion**

Atrial fibrillation is the most common complication after cardio-pulmonary bypass and its incidence appears to be increasing, presumably as a result of surgical patients becoming older and sicker\(^{[10]}\). While usually not a direct cause of postoperative mortality, it is an important cause of morbidity, increased length-of-stay and cost\(^{[2–5]}\). Several prophylactic strategies have attempted to reduce the incidence of this arrhythmia, including treatment with beta-blockers, sotalol or amiodarone as well as atrial pacing\(^{[6–9]}\). These strategies are themselves expensive and may possibly increase morbidity. More effective pre-operative risk stratification may identify a high-risk group in whom prophylactic therapy may be more cost-effective.

Several pre and postoperative factors have been associated with an increased incidence of postoperative atrial fibrillation including age, valvular surgery, hypertension, withdrawal of beta-blocker therapy and signal-averaged p-wave duration\(^{[10–14]}\). The hypothesis of the study that left atrial appendage emptying velocities would be predictive of postoperative atrial fibrillation was not confirmed by the results of the study which suggest that these measurements are not predictive of postoperative atrial fibrillation. In addition, left atrial size appeared unrelated to postoperative atrial fibrillation, a finding supported by other studies\(^{[18,19]}\). Given the link between left atrial size and function and atrial fibrillation in the general population, these findings support the contention that postoperative atrial fibrillation is a distinct entity with a different pathogenesis than the atrial fibrillation encountered in the non-surgical population. Possible distinct mechanisms for postoperative atrial fibrillation include pericardial injury incurred during surgery, systemic inflammatory state that may be induced by cardio-pulmonary bypass, or elevated sympathetic tone\(^{[29]}\).

An alternative explanation for our results is that transoesophageal echocardiography assessment of left atrial appendage function is not necessarily reflective of left atrial function. Previous studies with transoesophageal echocardiography support the use of left atrial appendage assessment as a surrogate marker of left atrial function\(^{[15–17]}\). As mentioned, the lack of correlation between left atrial size and postoperative atrial fibrillation in this and other studies supports the lack of correlation between left atrial function and the development of postoperative atrial fibrillation.

The major limitations of the study are its retrospective nature and potential selection bias. Patients were referred for pre-operative transoesophageal echocardiography for clinical indications therefore explaining the relatively high proportion of patients who subsequently underwent mitral valve surgery. It is important to note referral to transoesophageal echocardiography was generally unrelated to assessment of atrial function or atrial arrhythmias. However, given the retrospective nature of the study selection, bias cannot be excluded. Measurements of left atrial appendage function were made on-line prior to cardio-pulmonary bypass and assessment of arrhythmias were made by treating physicians unaware of the results of left atrial appendage assessment minimizing other potential sources of bias. Another possible limitation of the study is its relatively small size. The fact that there was no threshold below which atrial fibrillation consistently occurred supports the contention that a larger-sized sample would not significantly change the results.

In conclusion, transoesophageal echocardiography measurement of left atrial appendage function prior to cardio-pulmonary bypass does not appear to predict development of postoperative atrial fibrillation. Further studies are necessary to define risk factors identifiable by echocardiography to assist in the risk stratification of these patients prior to cardio-pulmonary bypass.

**References**


