

## Transthoracic Echocardiography for Precardioversion Screening during Atrial Flutter/Fibrillation in Young Patients

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### Summary

**Background:** Transthoracic echocardiography (TTE) is reliable for detection of thrombi in the left ventricle and right atrium, but not in the left atrial appendage. Therefore, transesophageal echocardiography (TEE) is routinely performed in adults prior to electric cardioversion for atrial flutter/fibrillation (AFF). Whether young survivors of congenital heart disease repair with AFF need routine TEE prior to electric cardioversion is unknown.

**Hypothesis:** Electric cardioversion for AFF is safe in survivors of congenital heart disease repair/palliation if an intracardiac thrombus is not suspected on TTE imaging.

**Methods:** This study reports the outcome of patients in a pediatric tertiary care cardiac unit where electric cardioversion was performed if no intracardiac thrombus was suspected on TTE. We performed a retrospective chart review of all patients treated with electric cardioversion for AFF at Children's Hospital of Michigan during 1997–2002

**Results:** Of 35 patients who presented with 110 episodes of AFF requiring electric cardioversion during the study duration, 32 (age 3 months–49 years, median age 20.5 years, 104 AFF episodes) had previously undergone palliative surgery or repair of their congenital heart disease. Of these 32 patients, 18 were survivors of a Fontan palliation (for a single-ventricle variant) and the remaining 14 were survivors of other defects and repairs (septal defects, valve replacements, and tetralogy of Fallot). During 81% of the episodes, patients were receiving

aspirin, warfarin, or heparin for anticoagulation at presentation. Transthoracic echocardiography was performed in 74 AFF episodes; of these, 10 TTE studies were suspicious for atrial thrombi. Transesophageal echocardiography confirmed the presence of a thrombus in 3 of these 10 patients. These patients received warfarin for 2 weeks and then underwent electric cardioversion. No thromboembolic events occurred immediately after or on follow-up in any patient.

**Conclusions:** These findings suggest that TTE may be an effective imaging tool for precardioversion screening in young patients with AFF.

**Key words:** atrial fibrillation, atrial flutter, cardioversion, echocardiography, intracardiac thrombi

### Introduction

Atrial flutter and atrial fibrillation (AFF) are supraventricular tachyarrhythmias that may be complicated by the development of atrial thrombi. In adults, the incidence of AFF is < 1% in subjects with normal cardiac anatomy who are aged < 60 years. The incidence rises to 16% in men and 13% in women aged > 80 years.<sup>1,2</sup> A similar high incidence of AFF has been reported in pediatric survivors of palliative surgery of complex congenital heart disease (CHD).<sup>3</sup> Direct damage to the sinus node or to its blood supply during surgery, conduction block at the suture line, and atrial dilatation all provide an electrophysiologic substrate that promotes spontaneous AFF.<sup>4–6</sup>

Atrial tachyarrhythmias are often poorly tolerated in survivors of complex CHD due to their coexisting hemodynamic alterations and are considered an important cause of morbidity and mortality.<sup>7</sup> Because of the potential for rapid development of ventricular dysfunction and hemodynamic compromise, cardioversion soon after diagnosis is the preferred treatment for these patients if there are no intracardiac thrombi.<sup>8</sup> This is in contrast to the therapeutic strategy of 3–4 weeks of anticoagulation prior to electric cardioversion in older patients with normal cardiac anatomy and normal ventricular function, who tend to tolerate AFF well if the ventricular rate is controlled.<sup>5</sup>

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Transthoracic echocardiography (TTE) is considered reliable for detection of thrombi in the left ventricle and right atrium; however, because TTE lacks the sensitivity to detect thrombi in the left atrial appendage, transesophageal echocardiography (TEE) is routinely performed in adults prior to electric cardioversion for AFF.<sup>9–12</sup> Survivors of CHD repair with AFF may be at higher risk of developing right atrial (versus left atrial) thrombi due to local stasis. Furthermore, the smaller chest dimensions of children and young adults often allow acceptable spatial resolution with TTE. The need for routine TEE in these subjects prior to electric cardioversion for AFF is unknown. We report the clinical outcome in a cohort of young patients at a pediatric tertiary care cardiac unit, in whom electric cardioversion was performed without TEE if a screening TTE demonstrated no intracardiac thrombus.

## Methods

After obtaining approval from the Institutional Human Investigation Committee, a retrospective chart review for all patients treated with electric cardioversion for AFF at our institution during 1997–2002 was performed. Charts were reviewed for patient clinical characteristics, results of imaging studies (TTE and TEE) performed during AFF and in sinus rhythm, effectiveness of electric cardioversion in restoring sinus/organized atrial rhythm, and patient follow-up after cardioversion.

## Results

### Patient Characteristics

A total of 35 patients presented with 110 episodes of AFF requiring electric cardioversion during the study duration. Of

these, 32 (age 3 months–49 years, median age 20.5 years, 104 AFF episodes) had previously undergone surgical palliation or repair for CHD. A single-ventricle variant (following palliative Fontan surgery) was the most common underlying diagnosis (18 patients, 73 AFF episodes). The remaining 14 patients had undergone surgery for other defects (Table I). The mean age at Fontan palliation was 3.8 years (median 1.6 years) and at first cardioversion was 17.3 years. Of the 18 patients, 17 underwent classic (atriopulmonary connection) and 1 patient underwent modified (intracardiac total cavopulmonary connection) Fontan procedure. During the study duration, 5 of the 17 patients with atriopulmonary connection underwent “revision” surgery to intracardiac total cavopulmonary connection due to recurrent AFF.

During 81% of AFF episodes, patients were receiving anti-coagulation or antiplatelet aggregation therapy at presentation prior to the onset of this arrhythmia (aspirin in 43 AFF, warfarin in 26 AFF, heparin in 4 AFF; Table I).

### Imaging Studies

Transthoracic echocardiography was performed during 74 AFF episodes. No imaging studies were performed prior to cardioversion in 30 episodes because the patient was either known to be on adequate anticoagulation or presented within hours of a clearly defined onset of AFF.

In most patients who underwent TTE, the right atrium and apical parts of the ventricles were well visualized. Because quantification of ventricular function by echocardiography is technically difficult in patients with single-ventricle anatomy or with a systemic right ventricle, it is based on subjective evaluation. Compared with previous imaging studies performed during sinus rhythm, 35% of TTEs during AFF showed normal cardiac function, 39% showed mildly impaired function,

TABLE I Clinical characteristics and echocardiography procedures in patient population

Cardiac disease	Intervention	No. of patients	N (AFF episodes)	Anticoagulation	Age (years) <sup>b</sup>	N (TTE)	N (TEE)	Thrombus location
ASD <sup>a</sup>	Percutaneous device closure	1	2	A = 2; W = 0; H = 0	45	2	0	
ASD	Surgical ASD closure	2	2	A = 1; W = 0; H = 0	26	2	0	
AVC	Surgical AVC closure	1	1	A = 0; W = 0; H = 0	0.3	1	0	
TOF	Transannular patch	1	2	A = 0; W = 2; H = 1	26	2	0	
TV Endo	TV replacement	1	4	A = 2; W = 0; H = 0	18	4	1 <sup>(T)</sup>	RA wall
Ebstein	TV replacement	1	1	A = 1; W = 0; H = 0	18	1	1	
DORV	Bi-ventricular repair	2	10	A = 10; W = 0; H = 0	28	9	0	
D-TGA	Mustard palliation	4	7	A = 2; W = 1; H = 1	20	6	0	
L-TGA	Rastelli operation	1	2	A = 2; W = 0; H = 0	25	2	0	
Single ventricle	Fontan palliation	18	73	A = 28; W = 23; H = 2	17	45	8 <sup>(T), (T)</sup>	RA roof
Total		32	104	A = 48; W = 26; H = 4	22	74	10	

<sup>a</sup> Percutaneous closure.

<sup>b</sup> Mean age at first cardioversion.

**Abbreviations:** ASD = atrial septal defect, AVC = atrioventricular canal, TOF = tetralogy of Fallot, DORV = double outlet right ventricle, D-TGA = (dextro) transposition of the great arteries, L-TGA = (levo) congenitally corrected transposition of the great arteries, TV = tricuspid valve, Endo = endocarditis, AFF = atrial flutter/fibrillation episodes, TTE = transthoracic echocardiogram, TEE = transesophageal echocardiogram, RA = right atrium, (T) = thrombus confirmed by TEE in 1 of AFF episodes, A = aspirin, W = warfarin, H = heparin.

and 26% showed severely impaired function. Ventricular function was normal during sinus rhythm in 70% (prior to onset of AFF or after conversion to sinus rhythm).

Ten TTE studies were considered suspicious for presence of atrial thrombi. Transesophageal echocardiography was performed in all 10 patients and confirmed the presence of an atrial thrombus in 3, all in the right atrium. Two of the three patients had undergone atriopulmonary Fontan palliation for single ventricle. At the time of AFF, there was mildly impaired ventricular function in one and severely impaired ventricular function in another patient. One patient had previous tricuspid valve replacement with an allograft with normal ventricular function at the time of AFF. All three patients received aspirin prior to onset of AFF and were treated with warfarin for 2 weeks after the diagnosis of atrial thrombus was confirmed by TEE; they subsequently underwent cardioversion. In seven patients in whom TEE did not demonstrate an intracardiac thrombus, TTE images were either of poor quality due to technical difficulties or interpreted slow blood flow in a dilated large right atrium (sometimes described as “smoke”) to be suspicious for thrombus.

### Cardioversion Treatment

Electric cardioversion was effective in restoring normal rhythm in all AFF episodes. No recognized thromboembolic events occurred immediately after cardioversion or during follow-up.

### Discussion

The majority of older adults presenting with spontaneous AFF, usually atrial fibrillation, have normal cardiac anatomy and tolerate this chaotic atrial rhythm well if the ventricular rate is controlled with interventions that slow atrioventricular conduction. Because of the risk of thromboembolism and stroke following cardioversion, the current management practice in these patients with AFF consists of anticoagulation with warfarin for 3–4 weeks prior to cardioversion.<sup>5</sup> This paradigm has been challenged recently by a study that demonstrated that in the absence of atrial thrombi on TEE, cardioversion may be performed immediately after the diagnosis of AFF without increasing the incidence of thromboembolic events/strokes, thus avoiding the need for prolonged anticoagulation prior to cardioversion.<sup>12</sup>

The results of our study suggest, however, that in a young population with CHD presenting with AFF, even routine TEE may not be necessary prior to electrical cardioversion. With TTE as the “screening” imaging modality and TEE limited to patients in whom TTE was suspicious of an intracardiac thrombus, none of the patients developed any clinically detectable systemic or pulmonary embolism following cardioversion, either acutely or on follow-up. These results have several potential explanations. First, because younger patients exhibit better spatial resolution due to a leaner habitus, TTE may have a higher sensitivity in detecting intracardiac throm-

bi in this population. Second, the majority of these patients were postoperative Fontan patients who are much more likely to develop stasis in their right than in the left atrium, and TTE may be adequately sensitive for detecting right atrial thrombus. Finally, younger subjects may be more likely to maintain the function of their left atrial appendage during AFF and may thus have a lower propensity for developing a thrombus in that location.<sup>13, 14</sup>

Due to right atrial hypertension and consequent distension, AFF is particularly common in those patients who underwent classic Fontan surgery (atriopulmonary connection).<sup>4, 7</sup> Antiplatelet aggregation prophylaxis with aspirin is a common practice in these patients and explains why the majority of patients underwent this therapy when AFF was first diagnosed. This surgery is no longer preferred in patients with single ventricles and has been replaced by modified Fontan surgery (total cavopulmonary connection) with the goal of decreasing the incidence of AFF in these patients. It should be noted that all three patients who developed an atrial thrombus during AFF (confirmed by TEE) received aspirin therapy. This finding suggests that aspirin is not very effective in preventing atrial thrombus formation in these high-risk patients.

### Study Limitations

This study is limited by its retrospective design and a small patient population. Furthermore, since TEE was performed only when TTE was suspicious for the presence of an atrial thrombus, the study does not estimate the sensitivity of TTE in detecting intracardiac thrombi. Finally, although no embolic events were reported in any patient, pulmonary perfusion was not routinely evaluated following electrical cardioversion in patients with right atrial stasis or enlargement. It is possible that asymptomatic, clinically insignificant microemboli to lungs from right atrial thrombi undetected by a screening TTE may occur with this strategy. Despite these limitations, the reported findings are important and hypothesis generating for this population. Larger, prospective multicenter studies with concurrent TTE and TEE may further help characterize the sensitivity of TTE in detecting intracardiac thrombi and could develop an effective strategy for managing these patients.

### Conclusion

In a management strategy that employed TTE as the screening imaging modality prior to electrical cardioversion, young patients with AFF had no thromboembolic events. This strategy needs to be evaluated prospectively in a larger cohort of young patients with AFF.

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