



# Early cardioversion of atrial fibrillation and atrial flutter guided by transoesophageal echocardiography

## A single centre 8.5-year experience

G. Corrado, M. Santarone, S. Beretta<sup>1</sup>, G. Tadeo, L. M. Tagliagambe, G. Foglia-Manzillo, M. Spata, E. Migliarina, F. Acquati and M. Santarone

Unità Operativa di Cardiologia, <sup>1</sup>Unità di Statistica e Biometria Ospedale Valduce Como, Italy

**Aims** To analyse the safety and impact on maintenance of sinus rhythm of transoesophageal echocardiographically guided early cardioversion associated with short-term anticoagulation in a large series of patients with atrial fibrillation and atrial flutter.

**Methods and Results** Patients who were candidates for cardioversion were eligible for inclusion if they had atrial fibrillation or atrial flutter lasting longer than 2 days or of unknown duration. Patients received short-term anticoagulation with warfarin or heparin and underwent trans-thoracic echocardiography followed by transoesophageal echocardiography. Early cardioversion was performed if no thrombus was seen on the transoesophageal study. Warfarin was maintained for 1 month after cardioversion. In patients with atrial thrombi, cardioversion was deferred and prolonged anticoagulation was prescribed. The study population included 183 patients. One hundred and sixty nine patients without atrial thrombi underwent early cardioversion. Fourteen patients with atrial thrombi (7.6%) underwent a second transoesophageal echocardiogram after a median of 4 weeks of oral warfarin, and cardioversion was performed if clot regression was documented.

No patient in our study population had a clinical thromboembolic event at 1 month follow-up (95% C.I. 0–0.016). The immediate success rate of cardioversion was better among patients with atrial fibrillation <4 weeks duration compared with patients with atrial fibrillation of longer or of unknown duration: 96.6% vs 85%, respectively ( $P=0.014$ ). At 1 month follow-up, the percentage of arrhythmia relapses in patients with initially successful cardioversion was similar in the two groups (29% vs 26%,  $P=ns$ ); thus the initial better outcome in patients with recent-onset arrhythmia was not lost.

**Conclusion** Transoesophageal echocardiography-guided early cardioversion in concert with short-term anticoagulation is safe. This approach permits abbreviation of the overall duration of atrial fibrillation and has a better impact on the maintenance of sinus rhythm for patients in whom the duration of atrial fibrillation is <4 weeks.

(Europace 2000; 2: 119–126)

© 2000 The European Society of Cardiology

**Key Words:** Atrial fibrillation, echocardiography, anticoagulation.

## Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia. Its prevalence increases with age and the presence of structural heart disease<sup>[1]</sup>. AF is characterized by lack of organized electrical and mechanical atrial activity that results in rapid ventricular response and

increased risk for heart failure, thromboembolism and death<sup>[2–5]</sup>.

Cardioversion (CV) of AF is employed both to prevent thromboembolism<sup>[6]</sup> and to improve ventricular function<sup>[7–11]</sup>. Unfortunately, in the absence of several weeks of preliminary anticoagulation CV itself may be complicated by clinical embolism in up to 7% of patients<sup>[12–14]</sup>. Previous studies have shown that anticoagulation with warfarin for 3–4 weeks before CV results in a substantial reduction in the incidence of CV-related thromboembolism<sup>[12–15]</sup>. Thus, the current standard of care provides for several weeks of prophylactic anticoagulation before CV of AF lasting longer than 2 days, or

Manuscript submitted 16 August 1999, and accepted after revision 30 December 1999.

*Correspondence:* Dr Giovanni Corrado, Unità Operativa di Cardiologia, Ospedale Generale Valduce Via Dante 11 22100 Como Italy. e-mail: [cardiologia@valduce.it](mailto:cardiologia@valduce.it)

of unknown duration; furthermore, anticoagulation should be continued until normal sinus rhythm has been maintained for 4 weeks<sup>[1,16]</sup>. However, this unselective anticoagulation strategy exposes the patient to prolonged warfarin therapy (with increased risk of haemorrhage<sup>[13,15]</sup>) and results in a 3–4 week delay in CV for the great majority of patients who would not experience thromboembolism.

Conventional transthoracic echocardiography has a low sensitivity for left atrial thrombus because of the small size of thrombi and their preferential location in the left atrial appendage. On the other hand transoesophageal echocardiography (TOE) is an excellent method of detecting atrial thrombi<sup>[17–21]</sup>. Its use has therefore been proposed to guide early CV in patients without atrial thrombosis in concert with short-term therapeutic anticoagulation with warfarin or heparin<sup>[15,22–24]</sup>.

We report on the results of an 8.5-year prospective study of a consecutive group of patients who have undergone TOE-guided early CV of AF or atrial flutter (AFL)>2 days' duration.

## Patients and methods

From August 1990 to January 1999 we evaluated 190 consecutive adults (inpatients and outpatients) with AF or AFL lasting longer than 2 days, or of unknown duration, who underwent TOE before scheduled external electrical cardioversion. Patients were excluded if they were on long-term anticoagulation, if AF/AFL duration was 2 days or less, or if TOE was contraindicated or refused. Seven patients were subsequently excluded because of inadequate TOE imaging of atria and appendages. After obtaining written informed consent, patients began receiving anticoagulation at their initial visit; the aim was to have patients therapeutically anticoagulated at the time of the planned CV. In 166 patients warfarin was initiated with a 5–10 mg loading dose and then INR levels were checked daily. TOE was performed as soon as INR levels were  $\geq 2$ . In ten patients, urgent CV was needed on haemodynamic grounds. They were anticoagulated with heparin using an intravenous bolus (10 000 U) and continuous infusion to maintain a partial thromboplastin time 1.5–2.5 times control values; in these patients a 3 to 4 day overlap of warfarin therapy and intravenous heparin therapy was necessary to maintain adequate anticoagulation after CV. Patients anticoagulated with warfarin or heparin received maintenance therapy with warfarin for 4 weeks after CV.

Seven patients were believed not to be candidates for anticoagulation.

Conventional transthoracic echocardiography was initially performed in all subjects with a commercial Hewlett Packard Sonos 500, 1000, 2000 or 5500 echocardiograph (Hewlett-Packard Andover Mass, U.S.A.) equipped with 2, 2.5, 5 MHz or with 4 s ultraband

transducers. M-mode left atrial dimension was measured in the parasternal long-axis view<sup>[25]</sup>.

In all patients, pre-cardioversion TOE was performed to screen for thrombus after at least a 4 h fast. Patients received posterior pharyngeal anaesthesia with 10% lidocaine spray and sedation with intravenous diazepam (5–10 mg). TOE was performed with a commercial 5 MHz single-plane probe or a 3.7–5 MHz omniplane probe (Hewlett-Packard Andover Mass, U.S.A.). The left atrial appendage was initially viewed in the horizontal (0°) plane; multiplane imaging was done by rotating the imaging sector from 0°–180° during continuous visualization of the appendage. An atrial thrombus was defined as a circumscribed and uniformly consistent echo-reflective mass of a texture different from that of the atrial wall<sup>[26]</sup>; in patients studied with multiplane TOE, off-axis views of the left atrial appendage were employed in order to differentiate thrombus from pectinate muscles<sup>[27]</sup>. Spontaneous echocontrast, a marker of blood stasis, was considered present when dynamic 'smokelike' echoes were seen within the atria that could not be eliminated by changes in gain settings<sup>[28]</sup>. Left atrial appendage areas and emptying velocities were not routinely determined. Imaging and Doppler data were recorded on videotape for consensus review by two experienced observers.

If no atrial thrombus was detected, external direct current CV was performed immediately after or within 24 h of TOE (paddle position: apex-R upper anterior chest wall). Because of the potential for thrombus formation during the interval between TOE and CV, in seven patients who did not receive anticoagulation, CV was performed immediately after TOE.

Patients with atrial thrombus on TOE received  $\geq 4$  weeks of warfarin therapy (INR  $\geq 2$ ). After this period, TOE was repeated and, if thrombus was no longer detectable, CV was planned. If clot was still present, CV was cancelled.

Patients were followed by an outpatient visit or a telephone call 4 weeks after CV.

## Statistical analysis

Results (Table 2) are expressed as mean value  $\pm 1$  SD. Categorical variables were compared using the Fisher's exact test. Continuous variables were compared using a t-test for unpaired data, assuming unequal variances in the case of duration of atrial fibrillation. Exact binomial 95% confidence intervals were calculated for frequency data. The presence or absence of thrombus was assessed by two observers (raters). The interrater agreement was assessed calculating the Kappa-statistic. A statistic for testing Kappa > 0 was calculated. All calculation were made using Stata 4.0 (Stata Co., 1984–1995, U.S.A.).

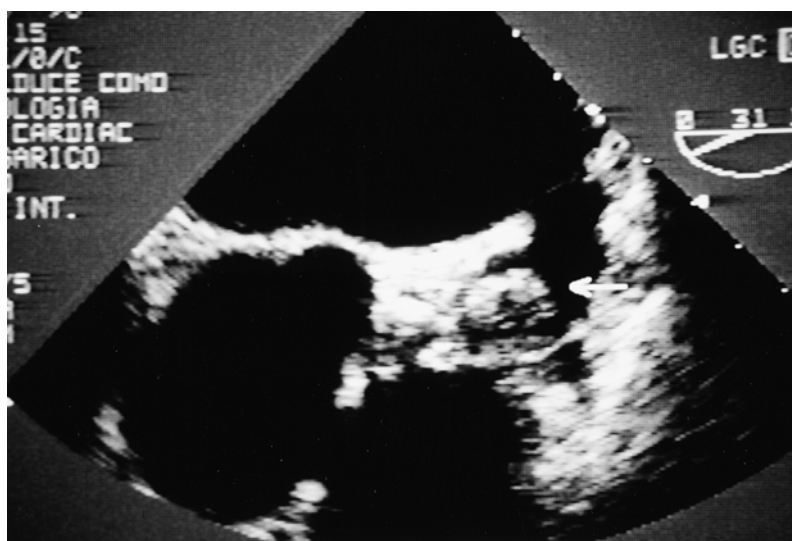
## Results

The study population included 183 patients (107 men and 76 women) aged  $64.4 \pm 8.3$  years (range 33–86). The

**Table 1** Primary associative disorders underlying atrial fibrillation/flutter

Underlying disease		N°	%
Valvular heart disease	mitral*	30	16.4
	aortic**	5	2.7
	mitral-aortic	8	4.4
Hypertension	uncomplicated	25	13.7
	hypertensive heart disease***	13	7.1
Ischaemic heart disease		15	8.2
AF/AFL related heart failure		13	7.1
Cardiomyopathies	dilated	21	11.5
	hypertrophic	4	2.2
Congenital heart disease		4	2.2
Pericarditis	constrictive	1	0.5
	effusive-constrictive	1	0.5
Precipitating illness	hyperthyroidism	3	1.6
	pneumonia	1	0.5
Lone AF/AFL****		39	21.3
Total		183	100

\*including seven patients with mitral valve prolapse; \*\*including one patient with an unanticoagulated biological valve prosthesis; \*\*\*increased left ventricular wall thickness (with or without left ventricular systolic dysfunction) in hypertensive patients; \*\*\*\*patients without overt cardiovascular disease or precipitating illness, independent of age. AF=atrial fibrillation AFL=atrial flutter.



**Figure 1** Multiplane transoesophageal echocardiogram of the left atrium and left atrial appendage (31°). The patient had AF of unknown duration; the transthoracic echocardiogram demonstrated the presence of mitral valve prolapse with moderate valve regurgitation. Note the multilobed appearance of the left atrial appendage which shows a definite bifurcation. A thrombus (white arrow) was detected in the medial portion of the branched left atrial appendage. After 4 weeks of warfarin this thrombus had completely resolved.

presenting arrhythmia was AF in 155 and AFL in 28 patients. Underlying disorders are summarized in [Table 1](#). The clinically estimated duration of AF/AFL was  $30.6 \pm 45.4$  days in 98 patients (range 3–180). In 85 patients (46%) the duration of AF/AFL was clinically indeterminate; they were mostly outpatients with asymptomatic arrhythmia.

Conventional two-dimensional and Doppler transthoracic echocardiography was initially performed in all patients. Transthoracic echocardiography did not detect intracardiac thrombus or spontaneous echo contrast or other sources of embolism in any patient. Uncomplicated TOE was subsequently performed with a commercial 5 MHz single-plane probe (early: 39 patients, 21%)

**Table 2** Clinical characteristics and echocardiographic data of patients with and without left atrial thrombi on transoesophageal echocardiography

	Left atrial thrombus		P value
	present (n=14)	absent (n=169)	
Age (years)	64.4 ± 8.5	64.2 ± 6.1	0.94
Gender (female)	5 (35.7%)	71 (42%)	0.78
Duration of AF/AFL (days)	41. ± 44.9*	35.2 ± 45.7**	0.76
Left atrial dimension (mm)	44.3 ± 4.7	42.2 ± 5.5	0.17
Left atrial spontaneous echocontrast	11 (78.6%)	68 (40.5%)	0.009
Hypertension	5 (35.7%)	71 (42%)	0.78
Structural heart disease of AF/AFL related heart failure	12 (85.7%)	104 (61.5%)	0.087

\*Unknown, n=9; \*\*Unknown, n=76. Data presented are mean values ± SD or number (%) of patients.

AF=atrial fibrillation AFL=atrial flutter

or with a 3.7–5 MHz omniplane probe (144 patients, 79%). Spontaneous left atrial echocontrast was detected by TOE in 79 patients (43%). In 169 out of 183 study participants (92.4%) TOE was negative for the presence of atrial thrombi. In 14 patients (7.6%) an atrial thrombus was identified on the pre-cardioversion TOE study. Atrial thrombi were sessile in 12 patients and mobile in two patients. In all patients, thrombus was located in the left atrial appendage (Fig. 1). The overall inter-observer agreement for the diagnosis of atrial thrombi was 95, 12% with Kappa=0.7066 ( $P<0.0001$ ). The study population with atrial thrombi on first TOE included nine men and five women aged  $64.4 \pm 8.5$  years. The underlying arrhythmia was AF in 12 patients and AFL in two patients. Spontaneous echocontrast was detected in 11 out of 14 patients with atrial thrombi (78.6%) and in 68 out of 169 patients without atrial thrombi (40.4%) (Table 2). Left atrial thrombi were more frequent among patients with structural heart disease or heart failure ( $P=0.087$ ) and among patients with left atrial spontaneous echocontrast ( $P=0.009$ ) (Table 2). Nevertheless, we found a substantial overlap between groups. Age, gender, hypertension, duration of AF/AFL, left atrial dimension were not different between patients with and without left atrial thrombi (Table 2). To summarize, none of the variables mentioned above was a reliable predictor of the presence of thrombus for a given patient.

In patients without atrial thrombi on first TOE external electrical cardioversion was performed immediately or within 24 h.

In patients with atrial thrombi on first TOE cardioversion was deferred and we performed a second TOE after a median time of 4 weeks (mean  $5 \pm 1.5$ , range 4–9) of therapeutic anticoagulation with warfarin. Eleven of 14 atrial thrombi had completely resolved (78.6%; 95% CI, 49 to 95%). Furthermore, no new atrial thrombi were visualized on follow-up TOE. Ten of 11 patients with documented thrombus resolution underwent subsequent electrical CV; in one patient cardioversion was deferred because of scheduled surgical pericardiectomy. In three patients with persistent atrial thrombus, CV was cancelled (Fig. 2).

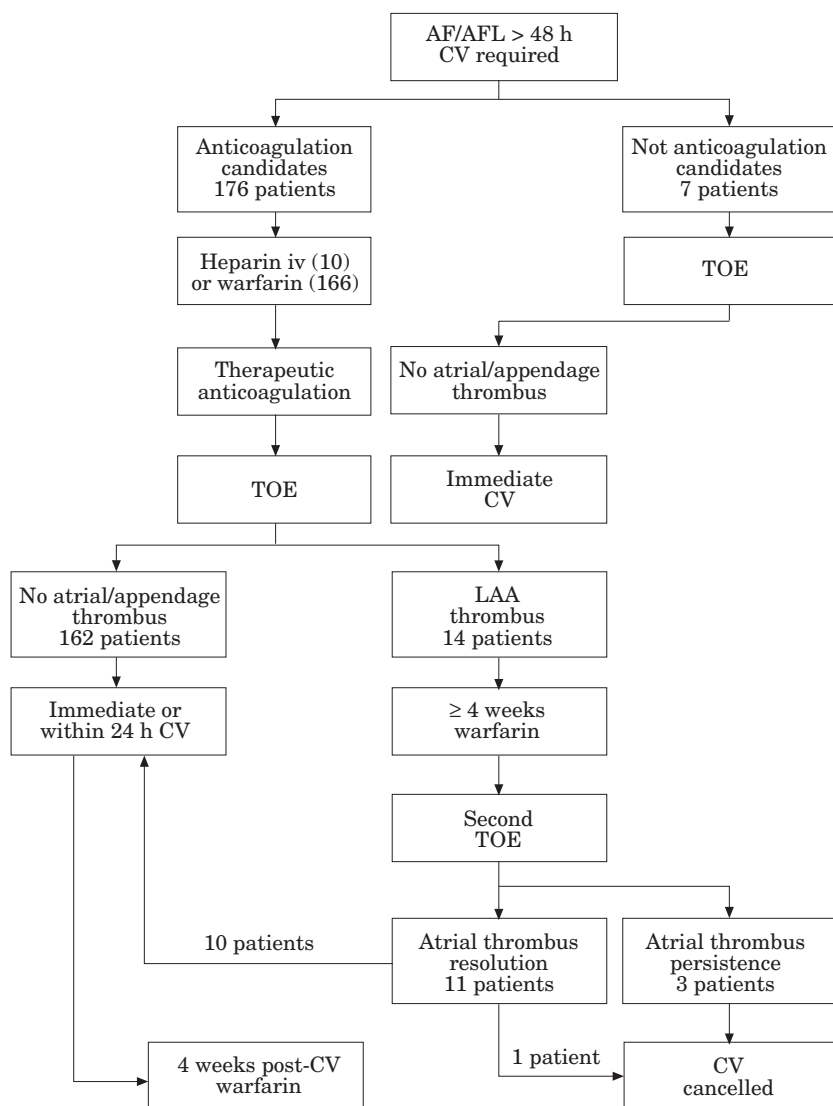
Eight patients with initially successful CV reverted to AF before the scheduled 4-week follow-up visit. If patients were therapeutically anticoagulated (seven of eight patients) a second electrical CV was performed without preliminary TOE; in one patient with subtherapeutic anticoagulation, a second TOE was performed before CV. In all cases, after the second CV the '1 month follow-up clock' was restarted.

In one patient, major bleeding occurred due to previously unrecognized colon cancer 2 days after CV; a conventional transthoracic echocardiogram revealed signs of persistent atrial stunning, with the A wave virtually absent on the pulsed Doppler examination of the mitral valve. Nevertheless, warfarin therapy was stopped and surgical removal of the cancer performed; the patient was found to be in sinus rhythm at 1 month of follow-up.

In seven patients, TOE and subsequent CV were performed without anticoagulant therapy.

At the 1 month follow-up, 112 of 159 patients with initially successful CV were still in sinus rhythm; three patients were lost to follow-up even though repeated attempts were made to get in touch with them. In one patient with severe aortic valve stenosis follow-up was interrupted after 5 days because of aortic valve replacement. As a whole, in our patients who underwent TOE-guided CV, the immediate and 1 month success rates of CV were 88% and 70%, respectively. Nevertheless, the immediate success rate of CV was better among patients with AF/AFL < 4 weeks duration (57/59, 96.6%) compared with patients with AF/AFL of longer or of unknown duration (102/120, 85%); this difference was statistically significant ( $P=0.014$ ). At the 1 month follow-up the percentage of AF/AFL relapses in patients with initially successful CV were similar between the two groups (29% vs 26%,  $P=ns$ ); thus, the initial better outcome in patients with recent-onset arrhythmia was maintained at long-term follow-up.

No patient had clinical evidence of cerebral or systemic embolism at 1 month follow-up after cardioversion (95% confidence interval 0–0.016).



**Figure 2** Schematic of patient flow (see text for details). AF=atrial fibrillation; AFL=atrial flutter CV=cardioversion; LAA=left atrial appendage TOE=transoesophageal echocardiography.

## Discussion

Our results suggest that TOE-guided cardioversion with short-term anticoagulation is feasible and safe and are in agreement with previously published data on this topic<sup>[15,22–24]</sup>.

Such an approach allows for a shortened total duration of anticoagulation (by eliminating the 3–4 weeks of pre-cardioversion warfarin). The incidence of major bleeding during warfarin therapy appears to be related to the length and to the intensity of anticoagulation<sup>[13,15]</sup>; a briefer anticoagulation therapy has the potential advantage of a decreased risk for bleeding. Furthermore, transient subtherapeutic INR during pre-CV warfarin therapy is not infrequent<sup>[15]</sup>; in these patients the '1 month clock' is generally restarted after adjusting the dose of warfarin, with a further delay in

CV. Seven patients in our series were found to be free of atrial thrombi on TOE and underwent subsequent uneventful CV without anticoagulation therapy. This approach was used in a limited number of patients in the early phases of our study (1991–1993). The exclusion of pre-existing atrial thrombi does not eliminate the risk of embolism after CV because of the possibility of post CV depressed left atrial and left atrial appendage mechanical function and de novo thrombosis<sup>[29–33]</sup>. Post CV atrial and appendage stunning appears to be independent of the modality of CV, and occurs with spontaneous<sup>[34]</sup>, pharmacological<sup>[35,36]</sup> or electrical<sup>[23,35–38]</sup> CV. Furthermore, which patients will exhibit atrial stunning cannot be predicted on pre-CV variables<sup>[39]</sup>. On the basis of these data, the use of 1 month warfarin after CV is strongly recommended to prevent new thrombi from forming during the period of recovery of atrial

mechanical function<sup>[15,22,24,40]</sup>. Nevertheless, in patients in whom anticoagulation is absolutely contraindicated, TOE-guided CV without anticoagulation appears to be safer than 'blind' CV<sup>[24,40]</sup>.

The use of TOE allows CV to be performed earlier. The duration of atrial fibrillation is the strongest predictor of long-term success of CV<sup>[41]</sup>. AF is recognized to cause electrical remodelling of the atria which may play a role in the development of chronic AF<sup>[42]</sup>. Furthermore, AF is associated with rapid left atrial and left atrial appendage functional and anatomical remodelling<sup>[43,44]</sup>. Finally, the time required for recovery of both atrial mechanical function and atrial electrophysiological properties is directly related to the duration of AF before CV<sup>[42,45]</sup>. Thus, since cardioverting patients with recent onset AF may avoid electrical and mechanical atrial remodelling, CV should probably be performed early once a decision to cardiovert has been made. The ACUTE Pilot Study compared immediate rates of conversion and long-term maintenance of sinus rhythm between the TOE-guided group and the conventional therapy (i.e. pre-CV 3 weeks warfarin) group. Disappointingly similar rates of immediate and long-term success of CV were found between the TOE and the conventional therapy groups (85% vs 76% and 55% vs 56%, respectively)<sup>[15]</sup>. As a whole in our patients who underwent TOE-guided CV immediate and 1 month success rates of CV were similar to the ACUTE population: 88% and 70%, respectively. Nevertheless, in our study population the immediate success rate of CV was better among patients with AF/AFL < 4 weeks duration compared with patients with AF/AFL of longer or of unknown duration ( $P=0.014$ ). Furthermore, the initial better outcome in patients with recent-onset arrhythmia was maintained at long-term follow-up. In patients with AF < 4 weeks duration, the conventional use of 3–4 weeks of prophylactic anticoagulation before CV significantly prolongs the overall duration of AF before CV. This delay potentially reduces the likelihood of recovery and maintenance of sinus rhythm.

The incidence of CV-associated thromboembolism in patients who received 1 month prophylactic anticoagulation is low, but is not zero<sup>[12–15]</sup>. The use of TOE to guide early CV could further decrease the risk of embolism-avoiding CV in patients with atrial and/or appendage thrombi. In our study population atrial thrombi were identified in 14 patients (7.6%). After a median of 4 weeks of warfarin 11/14 atrial thrombi had resolved; furthermore, no new thrombi were identified on follow-up TOE. Uneventful CV was attempted in patients with documented thrombus resolution. These findings on the benefit of anticoagulation are in agreement with previously published data<sup>[15,18,23,46,47]</sup> and support the hypothesis that the primary mechanism of thromboembolism reduction of 3–4 weeks of warfarin before CV are atrial thrombus resolution and prevention of new thrombus formation, rather than organization and adherence of any clot that is already present in the atrium. CV-related thromboembolism after 1 month of warfarin (i.e. in patients treated with conventional

therapy) could be related to unrecognized residual thrombi. Therefore, follow-up with TOE before CV is generally advocated to document thrombus resolution in patients found to have atrial thrombus on first TOE<sup>[15,24,40]</sup>. In patients with persistence of atrial thrombus the need for cardioversion to sinus rhythm should be weighed against the risk of embolization.

Cost-effectiveness models demonstrate that TOE-guided early CV of AF could be a cost-saving alternative to conventional therapy<sup>[48]</sup>. Furthermore, in patients with AF and atrial thrombi detected on first TOE, a strategy that uses a follow-up TOE to document thrombus resolution before CV could reduce the risk of post-cardioversion thromboembolism and may be more cost-effective than proceeding directly to CV after prolonged anticoagulation without follow-up TOE<sup>[49]</sup>. The direct comparison of the relative cost-effectiveness of conventional vs TOE-guided approaches to electrical CV for patients in AF is a secondary objective of the ongoing ACUTE multicentre study<sup>[15]</sup>.

In two patients with atrial thrombus on TOE the underlying arrhythmia was AFL (two thrombi out of 28 patients with AFL: 7%). AFL is an organized arrhythmia which has been traditionally considered to be at low or absent thromboembolic risk<sup>[14,50]</sup>. However, atrial thrombi and spontaneous echocontrast have already been reported in the literature in patients with AFL with or without structural heart disease<sup>[51–53]</sup>. These data suggest that, in contrast to the widely held belief that AFL is an organized rhythm with low risk of thromboembolism<sup>[14]</sup>, cardioversion of AFL in non-anticoagulated patients may be associated with increased risk of thromboembolic complications. Until further information becomes available, some authors recommend that patients with AFL be treated with anticoagulants in a similar manner to those with AF<sup>[40,54]</sup>.

### Study limitations

Our study was non-randomized, and so a true comparison between TOE-guided early CV and conventional anticoagulant prophylaxis before CV cannot be made.

Thirty-nine patients (21% of the study population) enrolled in the earlier phases of the study underwent TOE with a single-plane probe. Biplane and multiplane probes are more accurate than monoplane probes in atrial thrombi detection<sup>[20,21]</sup>. Thus, even if atria and atrial appendages were carefully studied in all patients, it is possible that some atrial thrombi may have been missed in patients studied with monoplane probes.

Our follow-up was limited to one month after enrollment. Thus the long-term success rate of CV cannot be drawn from our data.

### Conclusions

TOE-guided early CV in concert with short-term anticoagulation is feasible and safe. This strategy permits

abbreviation of the duration of AF/AFL with a more favourable impact on the maintenance of sinus rhythm. Further studies are necessary to compare directly the relative efficacy and cost-effectiveness of the TOE-guided strategy with the conventional 4 weeks of pre-CV warfarin in patients with AF/AFL scheduled for electrical CV.

We are indebted to the nurses Laura Zaffaroni and Mariangela Negretti for data collection.

## References

- [1] Prystowsky EN, Benson DW Jr, Fuster V, *et al*. Management of patients with atrial fibrillation. A statement for healthcare professionals from the Subcommittee on Electrocardiography and Electrophysiology, American Heart Association. *Circulation* 1996; 93: 1262-77.
- [2] McBride R. Stroke Prevention in Atrial Fibrillation study. Final Results. *Circulation* 1991; 84: 527-39.
- [3] Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation: a major contributor to stroke in the elderly. The Framingham study. *Arch Intern Med* 1987; 147: 1561-4.
- [4] Pritchett ELC. Drug therapy. Management of atrial fibrillation. *N Engl J Med* 1992; 326: 1264-71.
- [5] Benjamin EJ, Wolf PA, D'Agostino RB, Silbershatz H, Kannel WB, Levy D. Impact of atrial fibrillation on the risk of death. The Framingham heart study. *Circulation* 1998; 98: 946-52.
- [6] Petersen P, Godtfredsen J. Embolic complications in paroxysmal atrial fibrillation. *Stroke* 1986; 17: 622-5.
- [7] Morris JJ Jr, Entman M, North WC, Kong Y, McIntosh H. The changes in cardiac output with reversion of atrial fibrillation to sinus rhythm. *Circulation* 1965; 31: 670-8.
- [8] Grogan M, Smith HC, Gersh BJ, Wood DL. Left ventricular dysfunction due to atrial fibrillation in patients initially believed to have idiopathic dilated cardiomyopathy. *Am J Cardiol* 1992; 69: 1570-3.
- [9] Kiény JR, Sacrez A, Facello A, *et al*. Increase in radionuclide left ventricular ejection fraction after cardioversion of chronic atrial fibrillation in idiopathic dilated cardiomyopathy. *Eur Heart J* 1992; 13: 1290-5.
- [10] Shapiro W, Klein G. Alterations in cardiac function immediately following electrical cardioversion of atrial fibrillation to normal sinus rhythm. *Circulation* 1968; 38: 1074-84.
- [11] Morris JJ, Kong Y, North WC, McIntosh HD. Experience with cardioversion of atrial fibrillation and flutter. *Am J Cardiol* 1964; 14: 94-100.
- [12] Bjerkelund C, Orning OM. The efficacy of anticoagulant therapy in preventing embolism related to D.C. electrical conversion of atrial fibrillation. *Am J Cardiol* 1969; 23: 208-16.
- [13] Weinberg DM, Mancini GBJ. Anticoagulation for cardioversion of atrial fibrillation. *Am J Cardiol* 1989; 63: 745-6.
- [14] Arnold AZ, Mick MJ, Mazurek RP, Loop FD, Trohman RG. Role of prophylactic anticoagulation for direct current cardioversion in patients with atrial fibrillation or atrial flutter. *J Am Coll Cardiol* 1992; 19: 851-5.
- [15] Klein AL, Grimm RA, Black IW, *et al*. Cardioversion guided by transesophageal echocardiography: the ACUTE pilot study. A randomized controlled trial. *Ann Intern Med* 1997; 126: 200-9.
- [16] Laupacis A, Albers G, Dalen J, Dunn MI, Jacobson AK, Singer DE. Antithrombotic therapy in atrial fibrillation. *Chest* 1998; 114: 579S-589S.
- [17] Aschenberg W, Schluter M, Kremer P, Schroder E, Siglov V, Bleifeld W. Transesophageal two-dimensional echocardiography for the detection of left atrial appendage thrombus. *J Am Coll Cardiol* 1986; 7: 163-6.
- [18] Mügge A, Daniel WG, Haussmann D, Gódke J, Wagenbreth I, Lichtlen PR. Diagnosis of left atrial appendage thrombi by transesophageal echocardiography: clinical implications and follow-up. *Am J Card Imaging* 1990; 4: 173-9.
- [19] Lin SL, Hsu TL, Liou JY, *et al*. Usefulness of transesophageal echocardiography for the detection of left atrial thrombi in patients with rheumatic heart disease. *Echocardiography* 1992; 9: 161-8.
- [20] Manning WJ, Weintraub RM, Waksmonski CA, *et al*. Accuracy of transesophageal echocardiography for identifying left atrial thrombi. A prospective, intraoperative study. *Ann Intern Med* 1995; 123: 817-22.
- [21] Fatkin D, Scalia G, Jacobs N, *et al*. Accuracy of biplane transesophageal echocardiography in detecting left atrial thrombus. *Am J Cardiol* 1996; 77: 321-4.
- [22] Manning WJ, Silverman DI, Gordon SPF, Krumholz HM, Douglas PS. Cardioversion from atrial fibrillation without prolonged anticoagulation with use of transesophageal echocardiography to exclude the presence of atrial thrombi. *N Engl J Med* 1993; 328: 750-5.
- [23] Stoddard MF, Dawkins PR, Prince CR, Longaker RA. Transesophageal echocardiographic guidance of cardioversion in patients with atrial fibrillation. *Am Heart J* 1995; 129: 1204-15.
- [24] Manning WJ, Silverman DI, Keighley CS, Oettgen P, Douglas PS. Transesophageal echocardiographically facilitated early cardioversion from atrial fibrillation using short-term anticoagulation: final results of a prospective 4-5-year study. *J Am Coll Cardiol* 1995; 25: 1354-61.
- [25] Sahan DJ, DeMaria A, Kisslo J, Weyman A. Recommendations regarding quantitation in M-Mode echocardiography: results of a survey of echocardiographic measurements. *Circulation* 1978; 58: 1072-83.
- [26] Seward JB, Khandheria BK, Oh JK, Freeman WK, Tajik AJ. Critical appraisal of transesophageal echocardiography: limitations, pitfalls, and complications. *J Am Soc Echocardiogr* 1992; 5: 288-305.
- [27] Orsinelli DA, Pearson AC. Usefulness of multiplane transesophageal echocardiography in differentiating left atrial appendage thrombus from pectinate muscles. *Am Heart J* 1996; 131: 622-3.
- [28] Castello R, Pearson AC, Labovitz AJ. Prevalence and clinical implications of atrial spontaneous contrast in patients undergoing transesophageal echocardiography. *Am J Cardiol* 1990; 65: 1149-53.
- [29] Black IW, Hopkins AP, Lee LCL, Walsh WF. Evaluation of transesophageal echocardiography before cardioversion of atrial fibrillation and flutter in nonanticoagulated patients. *Am Heart J* 1993; 126: 375-81.
- [30] Black IW, Fatkin D, Sagar KB, *et al*. Exclusion of atrial thrombus by transesophageal echocardiography does not preclude embolism after cardioversion of atrial fibrillation. A multicenter study. *Circulation* 1994; 89: 2509-13.
- [31] Moreyra E, Finkelhor RS, Cebul RD. Limitations of transesophageal echocardiography in the risk assessment of patients before nonanticoagulated cardioversion from atrial fibrillation and flutter: an analysis of pooled trials. *Am Heart J* 1995; 129: 71-5.
- [32] Antonielli E, Pizzuti A, Gandolfo N, *et al*. Transesophageal echocardiography before cardioversion in patients with atrial fibrillation: usefulness and limits. *G Ital Cardiol* 1995; 25: 543-52.
- [33] Mehta D, Baruch L. Thromboembolism following cardioversion of 'common' atrial flutter. Risk factors and limitations of transesophageal echocardiography. *Chest* 1996; 110: 1001-3.
- [34] Grimm RA, Leung DY, Black IW, Stewart WJ, Thomas JD, Klein AL. Left atrial appendage 'stunning' after spontaneous conversion of atrial fibrillation demonstrated by transesophageal Doppler echocardiography. *Am Heart J* 1995; 130: 174-6.
- [35] Manning WJ, Silverman DI, Katz SE, *et al*. Temporal dependence of the return of atrial mechanical function on the

- mode of cardioversion of atrial fibrillation to sinus rhythm. *Am J Cardiol* 1995; 75: 624–6.
- [36] Harjai KJ, Mobarek SK, Cheirif J, Boulos LM, Murgu JP, Abi-Samra F. Clinical variables affecting recovery of left atrial mechanical function after cardioversion from atrial fibrillation. *J Am Coll Cardiol* 1997; 30: 481–6.
- [37] Grimm RA, Stewart WJ, Maloney JD, *et al.* Impact of electrical cardioversion of atrial fibrillation on left atrial appendage function and spontaneous echo contrast: characterization by simultaneous transesophageal echocardiography. *J Am Coll Cardiol* 1993; 22: 1359–66.
- [38] Botto GL, Molteni S, Lombardi R, *et al.* Atrial mechanical function after conversion of recent onset atrial fibrillation to sinus rhythm (Abstr). *Pace* 1998; 21: 813.
- [39] Grimm RA, Klein AL, Black IW, Stewart WJ, Pacheco TR, Kidwell GA. Can patients with atrial arrhythmia susceptible to postcardioversion thromboembolism be identified pre-cardioversion by clinical or echocardiographic parameters? (Abstr). *Circulation* 1993; 88 (Suppl I): 1–313.
- [40] Silverman DI, Manning WJ. Role of echocardiography in patients undergoing elective cardioversion of atrial fibrillation. *Circulation* 1998; 98: 479–86.
- [41] Dittrich HC, Erickson JS, Schneiderman T, Blacky AR, Savides T, Nicod PH. Echocardiographic and clinical predictors for outcome of elective cardioversion of atrial fibrillation. *Am J Cardiol* 1989; 63: 193–7.
- [42] Wijffels MCEF, Kirchhof CJHJ, Dorland R, Alessie MA. Atrial fibrillation begets atrial fibrillation. *Circulation* 1995; 92: 1954–68.
- [43] Rubin DN, Katz SE, Riley MF, Douglas PS, Manning WJ. Evaluation of left atrial appendage anatomy and function in recent-onset atrial fibrillation by transesophageal echocardiography. *Am J Cardiol* 1996; 78: 774–8.
- [44] Mitusch R, Garbe M, Schmücker G, Schwabe K, Stierle U, Sheikhzadeh A. Relation of left atrial appendage function to the duration and reversibility of nonvalvular atrial fibrillation. *Am J Cardiol* 1995; 75: 944–7.
- [45] Manning WJ, Silverman DI, Katz SE, *et al.* Impaired left atrial mechanical function after cardioversion: relationship to the duration of atrial fibrillation. *J Am Coll Cardiol* 1994; 23: 1535–40.
- [46] Collins LJ, Silverman DI, Douglas PS, Manning WJ. Cardioversion of nonrheumatic atrial fibrillation. Reduced thromboembolic complications with 4 weeks of precardioversion anticoagulation are related to atrial thrombus resolution. *Circulation* 1995; 92: 160–3.
- [47] Corrado G, Tadeo G, Beretta S, *et al.* Atrial thrombi resolution after prolonged anticoagulation in patients with atrial fibrillation: a transesophageal echocardiographic study. *Chest* 1999; 115: 140–3.
- [48] Seto TB, Taira DA, Tsevat J, Manning WJ. Cost-effectiveness of transesophageal echocardiography-guided cardioversion: a decision analytic model for patients admitted to the hospital with atrial fibrillation. *J Am Coll Cardiol* 1997; 29: 122–30.
- [49] Seto TB, Taira DA, Manning WJ. Cardioversion in patients with atrial fibrillation and left atrial thrombi on initial transesophageal echocardiography: should transesophageal echocardiography be repeated before cardioversion? A cost-effectiveness analysis. *J Am Soc Echocardiogr* 1999; 12: 508–16.
- [50] Kinch JW, Davidoff R. Prevention of embolic events after cardioversion of atrial fibrillation: current and evolving strategies. *Arch Intern Med* 1995; 155: 1353–60.
- [51] Bikkina M, Alpert MA, Mulekar M, Shakoor A, Massey CV, Covin FA. Prevalence of intraatrial thrombus in patients with atrial flutter. *Am J Cardiol* 1995; 76: 186–9.
- [52] Irani WN, Grayburn PA, Afridi I. Prevalence of thrombus, spontaneous echocontrast, and atrial stunning in patients undergoing cardioversion of atrial flutter. A prospective study using transesophageal echocardiography. *Circulation* 1997; 95: 962–6.
- [53] Corrado G, Sgalambro A, Mantero A, *et al.* Thromboembolic risk in atrial flutter: preliminary results of the Italian multicenter FLASIEC study (Abstr). *Circulation* 1998; (Suppl 1): 1–703.
- [54] Mayet J, RS More, GC Sutton. Anticoagulation for cardioversion of atrial arrhythmias. *Eur Heart J* 1998; 19: 548–52.