



Brief Report

Cardioversion of pre-excited atrial fibrillation leading to ventricular fibrillation- case report and review of literature



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ABSTRACT

Pre-excited, fast conducting atrial fibrillation (AF) is a serious life-threatening arrhythmia that requires urgent pharmacological or electrical cardioversion. When anti-arrhythmic medications fail to restore sinus rhythm, biphasic, direct current (DC) cardioversion is required. Appropriate synchronization of the DC shock with the QRS is crucial, however not easily achieved. Since the QRS-T complexes in pre-excited AF are severely distorted, the diagnosis of inaccurate synchronization may be overlooked. Here, we report a unique case where during electrical cardioversion of pre-excited AF with inappropriate synchronization on the T wave inadvertently resulted in ventricular fibrillation (VF), and review the literature.

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Pre-excited, fast conducting atrial fibrillation (AF) is a serious life-threatening arrhythmia that requires urgent pharmacological or electrical cardioversion. When anti-arrhythmic medications fail to restore sinus rhythm, biphasic, direct current (DC) cardioversion is required. Appropriate synchronization of the DC shock with the QRS is crucial, however not easily achieved in pre-excited AF. Since the QRS-T complexes in pre-excited AF are severely distorted, the diagnosis of inaccurate synchronization might be overlooked.

1. Case report

A 19 year-old man was admitted to the emergency room (ER) due to rapid palpitations and a pre-syncope episode. He was previously healthy, did not take any medications on a regular basis and his family history was negative for any heart conditions. ECG upon admission showed a baseline rhythm of atrial fibrillation with pre-excitation. Delta wave was positive in all precordial leads (V1–6) and inferior leads and negative in L1 and AVL (Fig. 1). This pattern is compatible with a left anterolateral accessory pathway (AP). The patient was stable hemodynamically, however he was symptomatic and with a recent history of pre-syncope. Therefore, attempts to restore sinus rhythm were pursued. Administration of intra-venous Procainamide did not terminate the arrhythmia, and DC cardioversion was pursued. After deep

sedation was administered, a synchronized 100 joules of biphasic energy were delivered, resulting in ventricular fibrillation (VF) (Fig. 2). It is apparent that inaccurate synchronization with the T wave while the external defibrillator was set at “paddles” showed a relatively small QRS complex with a large positive T wave, leading to “shock on T” and induction of VF. The rhythm was diagnosed immediately and a second non-synchronized 200 joule shock was delivered, successfully restoring sinus rhythm. ECG post cardioversion showed partial pre-excitation during sinus rhythm. The patient was admitted to the cardiology department and later underwent successful ablation of the AP (Fig. 3).

2. Discussion

During DC cardioversion, synchronization of the DC shock to the QRS complex is crucial to avoid current delivery during the vulnerable period of repolarization and deterioration to ventricular fibrillation. Synchronization is obviously not required in very fast ventricular rhythms such as ventricular fibrillation. Fast-conducting, pre-excited AF resulting in high ventricular rates due to conduction through an AP may result in bizarre wide QRS complexes that are difficult to distinguish from the T waves. We performed an electronic literature search for case reports similar to ours. All included papers had complete data and electrocardiographic recordings. Six case reports had been previously published; one even lethal (Table 1). In all these cases, the apparent reason for post-cardioversion VF was inaccurate synchronization with the T wave. The lead chosen for synchronization is usually either L2 or paddles, which are similar, although opposite in direction to lead L1. Other notable observations include location of the pathway (left-sided in all cases) and gender (man in all cases). The age was quite variable,

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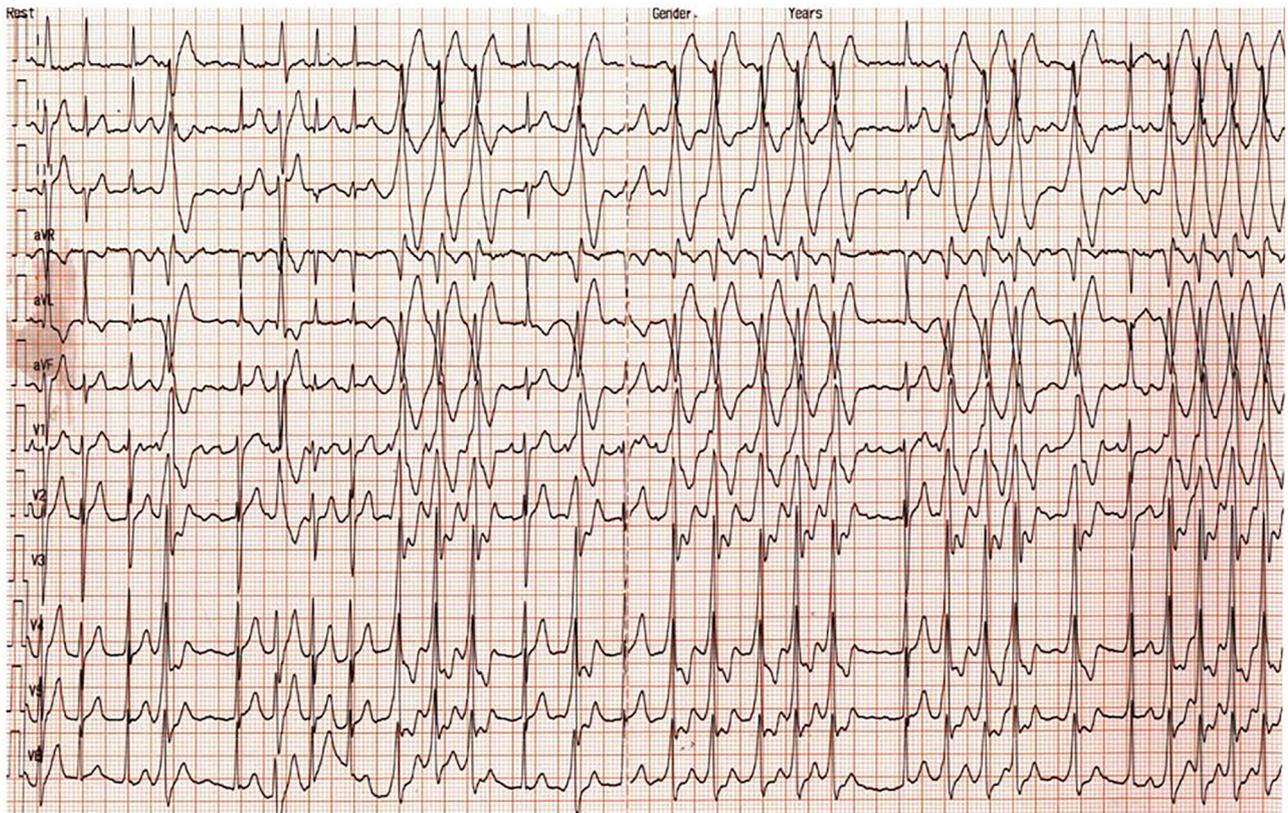


Fig. 1. 12 lead ECG on presentation, showing pre-excited atrial fibrillation using left anterolateral accessory pathway.

as was the presenting ventricular rate with a median of 245 beats per minute (bpm). In all but one case, the energy used was 100 joules or less. It has been suggested that lower shock energies predispose to VF [7]. The single case with induction of VF after the delivery of a 360

joule shock occurred during electrophysiological study, and information about use of medications such as Isoproterenol was not given.

Ayers et al. showed in a sheep model that DC cardioversion administered when the last cycle length is less than 300 milliseconds (200 bpm)

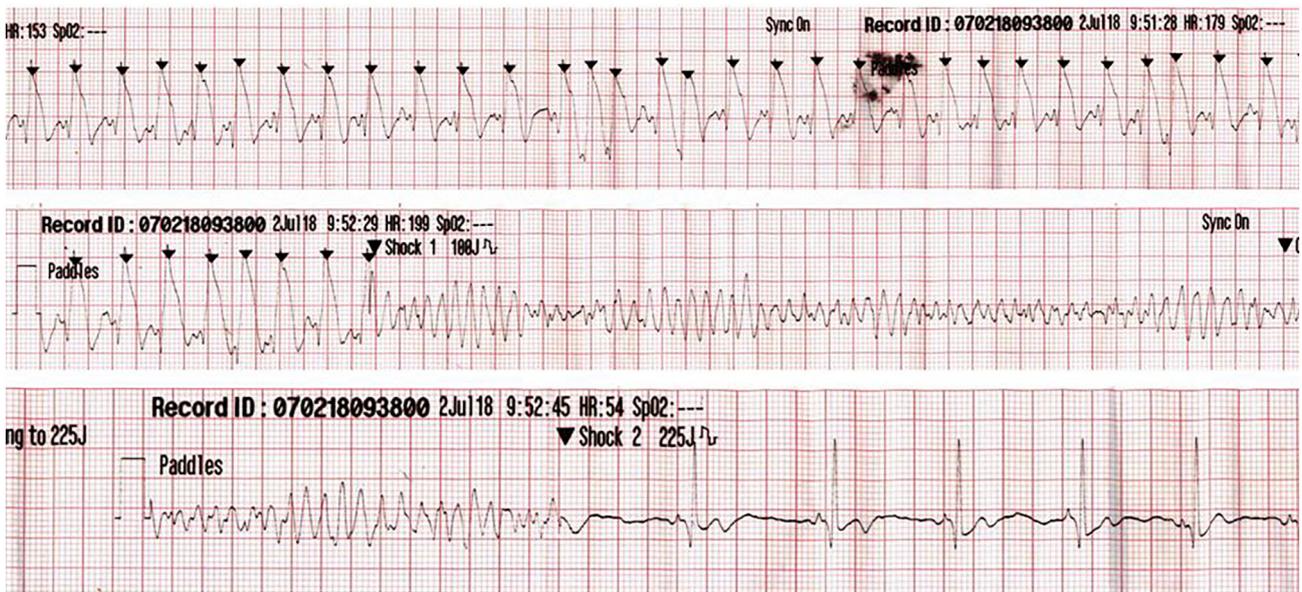


Fig. 2. Top, defibrillator paddles recording with synchronization on the T waves. Middle, 100 J DC shock delivery on the T wave resulting in ventricular fibrillation. Bottom, second, non-synchronization DC shock of 200 J restore sinus rhythm.

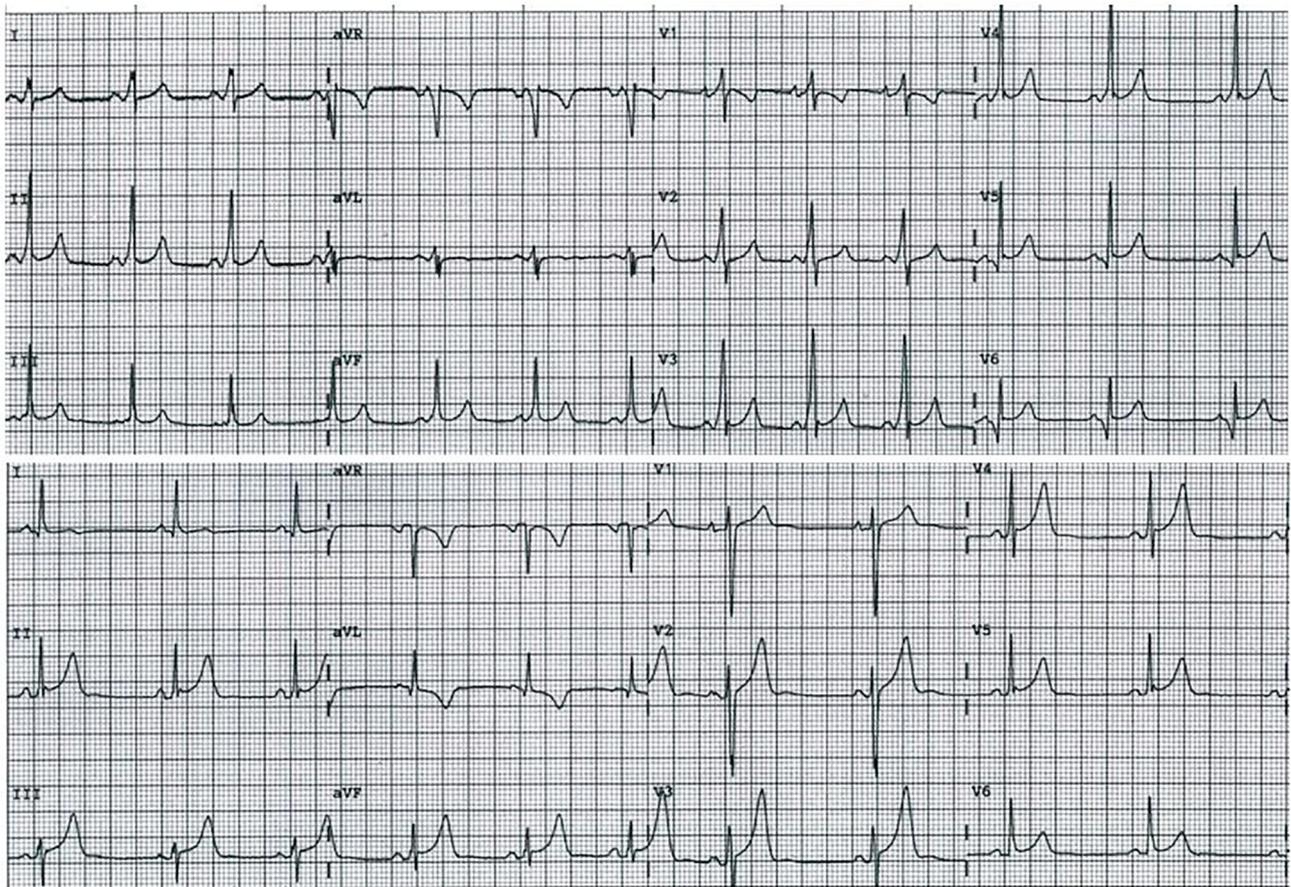


Fig. 3. Top, post cardioversion ECG showing sinus rhythm with pre-excitation. Bottom, post radiofrequency ablation ECG showing sinus rhythm without pre-excitation and with T memory changes.

may result in VF [6]. In fact, since the action potential duration of ventricular cells is in the range of 300 milliseconds (ms), it is logical to presume that some of the cardiac cells will still be in phase 3 of the action potential some 300 ms after the previous R wave. Usually, patients with rapid AF undergo some rate control using β blockers prior to the cardioversion. However, this is not the case in pre-excited AF as slowing the conduction over the atrioventricular node may increase the pre-

excited ventricular rate. Nevertheless, VF induction occurred only when the synchronization was inaccurately done. Thus, it seems that induction of VF requires the delivery of DC shock while a relatively large part of the heart is still in the vulnerable period of repolarization of the action potential.

Fig. 4 shows appropriate synchronization prior to DC cardioversion in a patient with atrial fibrillation and no pre-excitation. The narrow

Table 1
Patient characteristics.

Case	Gender	Age (years)	Tachycardia	Ventricular rate (bpm)	Initial management	Result	AP location	Reference
1	M	76	Pre-excited AF	150	Synch DC shock 100 J, synch- Lead II	VF, immediate DC shock to sinus, AP ablation	LPL	[1]
2	M	29	Pre-excited AF	250	Synch DC shock 50 J, synch- Lead II	VF, failure to defibrillate, death	LPL	[2]
3	M	23	Pre-excited AF	300	Synch DC shock	VF, CPR and intubation, DC shock to sinus, AP Ablation	LPL	[3]
4	M	23	Pre-excited AF	280	IV Adenosine, Amiodarone, procainamide AF during EPS- synch DC 360 J- paddles	VF, immediate DC shock to sinus, AP ablation	LPL	[4]
5	M	30	Pre-excited AF	240	Unrecognized pre-excitation Synch DC shock 100 J, synch- Lead II- DC shock, 100 J	CPR for 20 min, than DC shock to sinus; ICD	LPL	[4]
6	M	30	Pre-excited AF		DC shock, 100 J	VF, immediate DC shock to sinus, AP Ablation	LL	[5]
7	M	19	Pre-excited AF	180	IV Amiodarone, Procainamide, synch- paddles DC shock 100 J	VF, immediate DC shock to sinus, AP Ablation	LAL	Current

AF, atrial fibrillation; AP, accessory pathway; CPR, cardiopulmonary resuscitation; EPS, electrophysiological study; J, Joules; LPL, left posteroseptal; LL, left lateral; LAL, left anterolateral; M, male; VF, ventricular fibrillation.

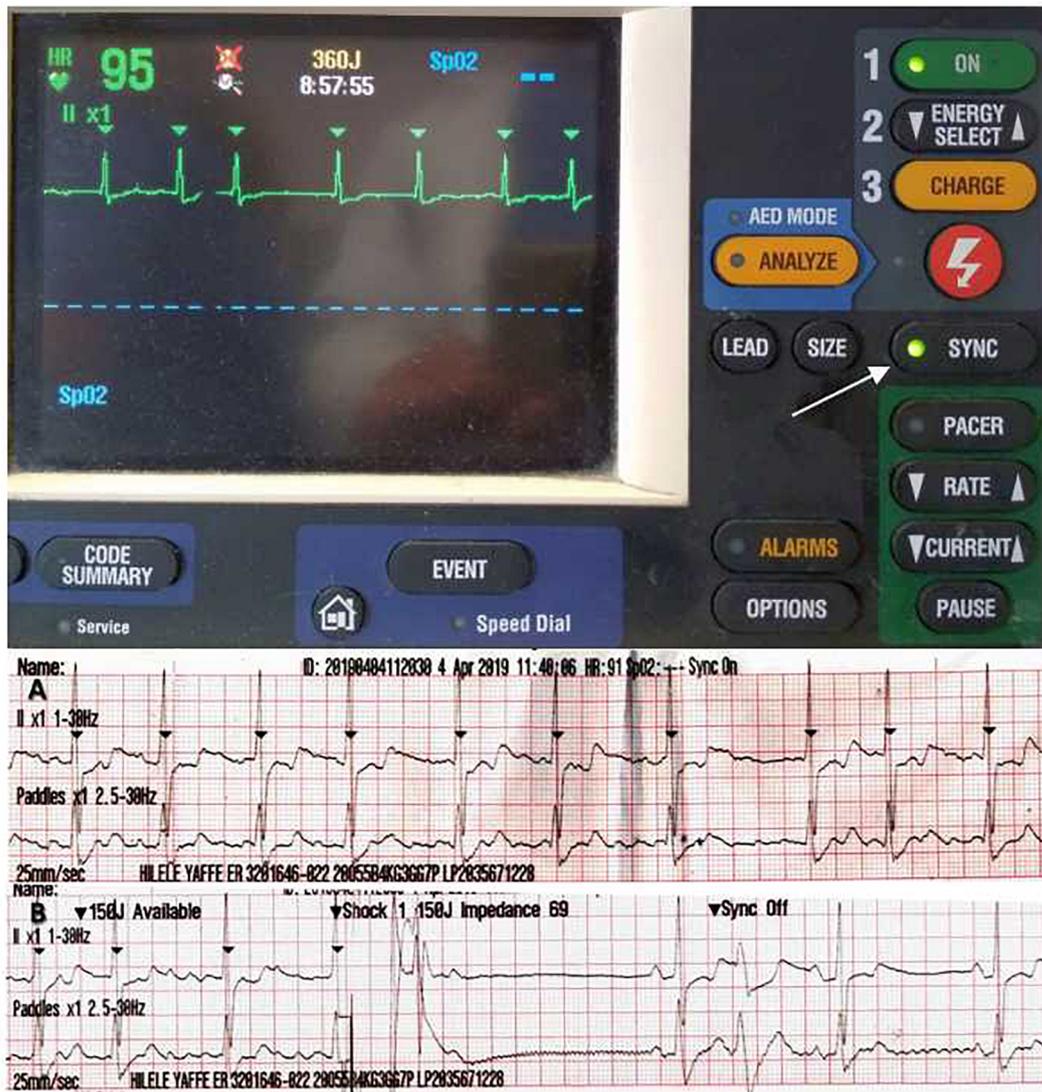


Fig. 4. Appropriate synchronization in a patient with atrial fibrillation and normal QRS. Top. External defibrillator showing the appropriate green triangles above each R wave. The white arrow points to the SYNCH button. Bottom, ECG strip during the DC cardioversion showing the appropriate synchronization and delivery of the energy on the R wave. Note that the synchronization is turned off automatically after the DC shock.

QRS and small, flat T waves enables accurate synchronization. Each synchronized beat is marked both on the monitor and in the printed ECG below. If not accurately marked by the defibrillator, one may change lead, increase the QRS gain or change the position of lead patches (not the defibrillator's patches). Most monitor-defibrillators allow the use of only two possible vectors- Lead II and the defibrillator patches. It should be noted that on occasion, the first DC shock fails to restore sinus rhythm and one may decide to increase the current delivery and administer a second shock. The external defibrillator automatically turns off the synchronization after every DC shock (Fig. 4, bottom), and one should press the SYNCH button again before delivery of another DC shock.

3. Conclusion and recommendations

Cardioversion of pre-excited, fast conducting AF may result in VF due to abnormal synchronization with the T wave. Lead choice should take into account the ability to accurately identify the QRS

complexes. It seems that the defibrillator's nominal setting (L2 and paddles), may not be suitable for synchronization in all cases and therefore careful lead and gain selection should be performed before delivering a DC shock. In patients with pre-excited AF undergoing DC cardioversion, one should verify appropriate synchronization on the QRS prior to seating the patient (Fig. 5). If the synchronization is not accurate, the first option is to change the position of lead left leg and right arm connection (responsible for the plus and minus of lead II, respectively). One may choose a lead with small T wave in the 12 lead ECG and try to connect the above connections according to that lead (i.e., for lead I, the left leg connection should be connected to the left arm). If the synchronization is still inaccurate, two options are possible: 1) in an unstable patient, the cardioversion may be administered without synchronization in a setting that enables resuscitation should the patient develop VF. Awareness to the possibility of developing VF is crucial. 2) If the patient is stable, administration of anti-arrhythmic drug may be continued in hope to return to sinus without the need for electrical cardioversion. If the patient remains

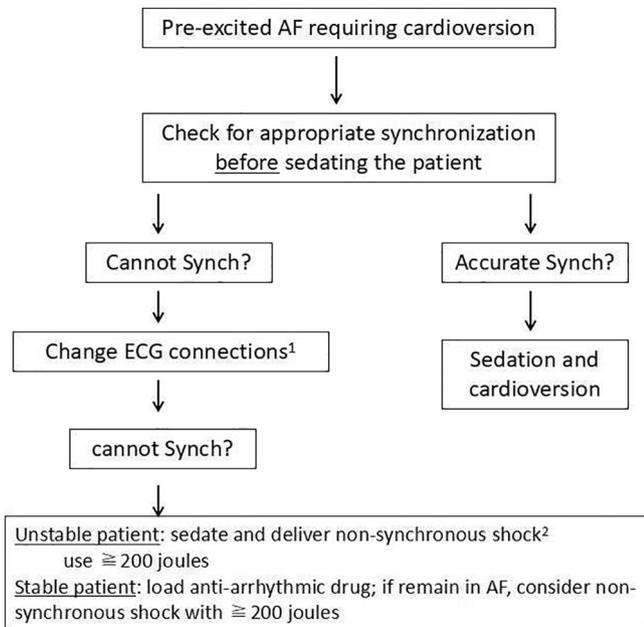


Fig. 5. Algorithm for cardioversion of pre-excited Atrial fibrillation. AF, atrial fibrillation; Synch, synchronization. ¹See text for options. ²Should be performed in a setting that enables immediate resuscitation.

in AF, one may perform non-synchronous cardioversion in an intensive care unit. Whenever non-synchronous shock is delivered, despite the paucity of data, we recommend using higher energy of at least 200 joules [7].

Disclosure

None.

References

- [1] Xavier LC, Memon A. Synchronized cardioversion of unstable supraventricular tachycardia resulting in ventricular fibrillation. *Ann Emerg Med* 2004;44(2).
- [2] Ebrahimi R, Rubin SA. Electrical cardioversion resulting in death from synchronization failure. *Am J Cardiol* 1994;74:100.
- [3] O'Connell M, Bernard A. Serious cause of panic attack case reports in emergency. *Medicine* 2012. <https://doi.org/10.1155/2012/393275>.
- [4] Kaufmann MR, McKillop MS, Burkart TA, Panna M, Conti JB, Miles WM. Iatrogenic ventricular fibrillation. *Tex Heart Inst J* 2018;45:39–41.
- [5] Adlam D, Azeem T. Ventricular fibrillation during electrical cardioversion of pre-excited atrial fibrillation. *Postgrad Med J* 2003;79:297.
- [6] Ayers M, Alferness CA, Ilna M, Wagner DO, Sirokman WA, Adams JA, et al. Ventricular proarrhythmic effects of ventricular cycle length and shock strength in a sheep model of transvenous atrial defibrillation. *Circulation* 1994;89:413–22.
- [7] Gallagher MM, Yap YG, Padula M, Ward DE, Rowland E, Camm AJ. Arrhythmic complications of electrical cardioversion: relationship to shock energy. *Inter J Cardiol* 2008;123:307–12.