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Review Article

Electrical Cardioversion of Atrial Fibrillation

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ABSTRACT

Cardio version is widely used in patients with Atrial Fibrillation (AF) when a rhythm control strategy is pursued. We sought to summarize the current evidence on the management of patients with AF, in particular electrical cardio version, taking into account the effectiveness criteria of the procedure, its various complications and the risk factors for recurrence.

Keywords: Atrial fibrillation; Cardiac arrhythmia; Modalities; Epidemiological

INTRODUCTION

Atrial Fibrillation (AF) is the most common cardiac arrhythmia. It represents a major cause of morbidity and mortality linked to thromboembolic events and heart failure, representing a considerable burden on patients and healthcare services. Despite extensive research, the underlying mechanisms of AF remain incompletely understood. The management of the disease has evolved over time with the emergence of a new therapeutic paradigm placing rhythm control at the forefront. This article summarizes current knowledge on the different modalities as well as the complications of cardioversion of AF [1].

LITERATURE REVIEW

Incidence and prevalence of AF

AF affects approximately 33 million people worldwide and more than 3 million in the United States. By 2030, the incidence of AF will reach 2.6 million cases in the United States, with its prevalence increasing to 12.1 million cases. In the same direction, the Framingham study noted an increase in the incidence and prevalence of AF, but with an improvement in survival secondary to better management of this condition. Epidemiological studies highlight the need for public awareness, early detection, adequate treatment of AF and control of modifiable risk factors [2].

Cardioversion of AF

The management of AF emphasizes 3 strategies summarized in the “ABC” diagram of the 2020 European Society of Cardiology (ESC) guidelines; these are "A" for anticoagulation/avoid stroke, "B" for better symptom control through rate and rhythm management and "C" for treatment of concomitant cardiovascular conditions [3].

Anticoagulation: Oral anticoagulation (Direct Anticoagulants (DOACs) or Vitamin K Antagonists (VKAs)) remains the first-line treatment to prevent thromboembolic events in patients with AF. Current guidelines recommend using AVKs in valvular AF (moderate to severe mitral stenosis, mechanical prostheses) regardless of the CHA 2 DS 2-VASc score and favoring DOACs in non-valvular AF if the CHA 2 DS score 2-VASc ≥ 2 and in elderly patients with cognitive impairment or poor therapeutic compliance (1.5).

Meta-analyses have demonstrated the association of DOACs with a reduced risk of stroke, intracranial hemorrhage and all-cause mortality. Estimation of bleeding risk should also be part of the routine management of patients with AF. The HAS-BLED score makes it possible not only to estimate the bleeding risk but also to correct modifiable risk factors (uncontrolled hypertension, labile INR, concomitant use of antiplatelets and non-steroidal anti-inflammatories and harmful alcohol consumption). Despite a high HAS-BLED score; the significant ischemic risk requires continuation of anticoagulation with regular monitoring and consideration of modifiable bleeding factors [4].

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Stroke prevention with adjusted dose warfarin is effective with aspirin alone or combined with clopidogrel, whereas the administration of aspirin alone is no longer recommended for the prevention of cardioembolic strokes. In case of contraindication to anticoagulants, occlusion of the left atrial appendage represents a second alternative to prevent thromboembolic events [5].

Anticoagulation peri and post cardioversion: Oral anticoagulation treatment should be initiated immediately in all patients scheduled for cardioversion and maintained for at least 4 weeks by assessment of the CHA 2 DS 2-VASc score. Cardioversion can be performed safely, if no left atrial thrombus is identified, provided that sufficient anticoagulation is obtained before Transesophageal Echocardiogram (TEE). If a thrombus is identified on TEE, appropriate anticoagulation is recommended for at least 3 weeks, before a repeat TEE is performed to ensure resolution of the thrombus.

There is increasing evidence that non-vitamin K antagonist oral anticoagulation can be used safely for stroke prevention in patients undergoing cardioversion of AF. Recent meta- analyses have demonstrated low rates of thromboembolic events and major bleeding in patients with AF undergoing cardioversion on DOACs. It should also be noted that the use of DOACs results in more rapid cardioversion and a decreased stroke rate compared to the use of warfarin. But the major concern when performing cardioversion under DOACs is to ensure compliance, because unlike VKAs, there is currently no test to monitor the quality of peri-procedural DOACs treatment [6].

Imaging prerogative in cardio version: TEE is the gold standard for excluding thrombus formation; its sensitivity can be improved by ultrasound contrast agents and by the use of three-dimensional TEE as well as tissue Doppler imaging.

The presence of low flow velocities (<40 cm/s) and spontaneous contrast in echocardiography reveal the identification of thrombus in the Left Atrial (LA) and thromboembolic events. Currently, cardiac Computed Tomography (CT) and cardiac Magnetic Resonance (MRI) are emerging as new means to evaluate the anatomy and function of the GA without significant difference in sensitivity or specificity [7].

The cardiac CT shows high diagnostic accuracy for detection of thrombus in GA in delayed imaging. It allows differentiation between thrombi and low blood flow. Despite its reliability, this examination can cause nephropathy due to the contrast product, particularly in patients with chronic renal failure and exposure to radiation.

Cardiac MRI has a high temporal resolution allowing visualization of the size and function of the GA, but this examination cannot be performed in patients with implanted cardiac devices (Figure 1) [8].

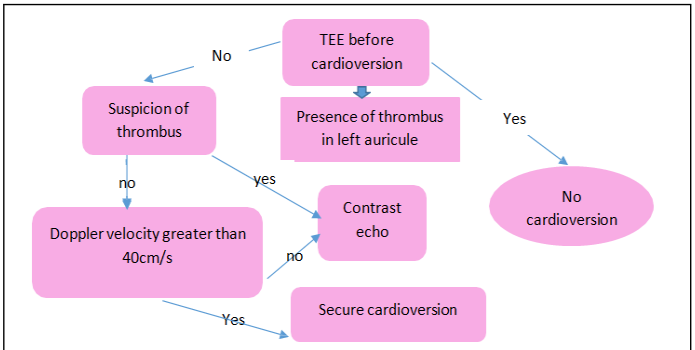

Figure 1: Left atrial assessment algorithm before cardioversion.

Rhythm control: Early rhythm control in patients with newly diagnosed paroxysmal AF has shown promising results in maintaining sinus rhythm and preventing progression from paroxysmal AF to persistent or permanent AF [9].

The EAST-AFNET 4 study revealed that patients assigned to early rhythm control compared to usual care (rate control plus oral anticoagulants with added rhythm control according to ESC and EC guidelines AHA/ACC/HRS) show a 21% reduction in deaths from cardiovascular causes, stroke (ischemic or hemorrhagic) or hospitalization with worsening heart failure or acute coronary syndrome. Similarly, a recent subanalysis of EAST-AFNET4 found a consistent beneficial effect of early rhythm control compared to usual care, whether the patient was symptomatic or asymptomatic [10].

Regarding quality of life, recent trials have shown that event-free survival (total mortality, symptomatic stroke, systemic embolism, major hemorrhage, heart failure and physical/psychological disability) was significantly better for rhythm control [11].

Rhythm control method

Electrical Cardioversion (ECV): ECV is a common procedure in patients with AF to restore sinus rhythm, relieve symptoms and delay disease progression. Acute success rates of electrical cardioversion range from 50% to 90%. The success of cardioversion in patients with AF depends on certain parameters: waveform, shock energy, manual pressure and positioning of the pads [12].

The waveform and shock energy: High-energy biphasic shocks >200 days can increase the effectiveness of restoring sinus rhythm (recent AF) and reduce the number of shocks, the risk of occurrence of Ventricular Fibrillation (VF) and the use of Antiarrhythmic drugs (AAR) after the procedure [13].

Increasing energy escalation protocols have similar cumulative success as high energy protocols. Observational series have suggested that the effect may be even more pronounced in patients with longer AF durations. In the same direction, the BEST-AF study found no difference in cardioversion success between fixed energy (200-200-200 J) and low escalation energy (100-150-200-200 J) shock groups [14].

Conversely, other studies have shown that low-energy shocks are ineffective but can reduce skin burns, patient discomfort and

myocardial damage. These shocks require less sedation and reduce the overall duration of the procedure.

The study of Anders S Schmidt supported the ineffectiveness of low escalation energy shocks compared to maximum fixed energy shocks, but with no difference in safety parameters between the 2 types of shocks.

Manual pressure: The success of ECV also depends on the critical muscle mass defibrillated and the delivery of sufficient electrical current to the heart, determined by the energy shock and by the magnitude of The Transthoracic Impedance (TTI), if this is low, by the manual pressure applied to the defibrillator paddles, the transmyocardial current and the shock delivered would be sufficient to achieve ECV, while an increased ITT will generate an insufficient current to achieve cardioversion [15].

Position of the electrodes: The optimal position of the electrodes remains unclear. Some studies have found no difference in the success of cardioversion when comparing the anteroposterior position to the anteroapical/lateral position of the pad. The Canadian cardiovascular society guidelines explain that electrode positioning does not appear to impact effectiveness and that manual pressure may facilitate cardioversion in obese patients.

While some studies have shown that ECV with an antero-lateral electrode position reduces the number of shocks compared to an antero-posterior position, as the antero-lateral shock vector can result in an overall cardioversion of more large number of myocardial cells unlike the anteroposterior vector which selectively targets the left atrium. In addition, the anterolateral positioning of the electrodes is more effective, not only because of its speed during immediate cardioversion (implantation of a pacemaker or ablation of the AF), but also during transcutaneous stimulation.

In contrast, the 2020 European Society of Cardiology guidelines explained that anteroposterior pad placement is more effective, a practical guidance document published by the European Heart Rhythm Association in 2020 states that anteroposterior pad placement is more effective than antero-apical placement.

Orthogonal cardio version: In case of paroxysmal AF refractory to the standard biphasic shock protocol (three subsequent shocks of increasing energy and/or two or three initial shocks with a maximum energy of 200J), Orthogonal Electrical Cardioversion (OECV) at low or medium energy (100-J to 300-J) may be a strategy useful rescue. It creates two distinct current pathways to deliver higher energy, thereby increasing the amount of defibrillated muscle mass. The orthogonal configuration decreases the defibrillation threshold through the capability of sequential pulses applying a more efficient and uniform current density, and changes the directional electrical vector during sequential shocks could facilitate cardioversion [16].

In obese patients suffering from chronic AF resistant to monophasic shocks and presenting a high ITT, double high-energy transthoracic shocks should be considered.

Pharmacological Cardio Version (PCV) by AAR

In cases of recent or paroxysmal AF without underlying cardiac involvement, PCV is effective with the administration of class Ic AARs (flecainide, propafenone) or vernakalant preferably intravenously.

In cases of persistent AF, PCV with oral amiodarone or sotalol for 1 month is modest (success rate at 25%). It can also be done by chronic administration of flecainide and propafenone despite the occurrence of rapid ventricular rates requiring hospitalization to control the potential adverse effects of AARs.

AARs are associated with excess mortality in patients with a history of myocardial infarction, impaired left ventricular function and ventricular ectopy, probably attributable to their negative proarrhythmic or inotropic effects.

Regarding dronedarone, studies have shown that this drug Although it was less effective than amiodarone in terms of reducing AF recurrence, it was more robust in patients with a history of AF<3 months and it should not not be used in patients with permanent AF, heart failure with reduced ejection fraction or patients with recent decompensation/hospitalization for heart failure or if high-risk flutter, dronedarone has been associated with adverse effects undesirable.

The pharmaceutical industry continues to seek more effective and safer AARs such as small conductance calcium-activated potassium channel (SK) inhibitors, TWIK-related acid sensitive potassium channel inhibitors (TASK-1), slow sodium channel inhibition and multichannel inhibitors.

DISCUSSION

Ablation of AF

Radiofrequency ablation of AF (pulmonary vein isolation) has proven to be more effective than AAR in maintaining sinus rhythm, particularly for symptomatic patients who are naïve to rhythm control or when there is failure of AAR.

AF burden and recurrence were less frequent in the ablation group compared to the AAR group. However, the CABANA study added that the risk of death, disabling stroke, serious hemorrhage or cardiac arrest was not different between the 2 arms. Early ablation in patients with concomitant AF and heart failure have shown effectiveness not only in terms of restoration of sinus rhythm, but also improvement in left ventricular ejection fraction. More recent trials support the clear benefit of first-line ablation of symptomatic AF with significant reductions in mortality, stroke and hospitalizations, particularly in the setting of congestive heart failure.

Although left atrial catheter ablation may be the best therapy, resources and complications due to its complex conventional nature (collateral damage to surrounding organs and structures) do not allow its use for all patients (Table 1) [17].

Table 1: Comparison between ablation and PCV by AAR.

	Ablation	PCV
Indication	Symptomatic paroxysmal AF AAR failure rhythm control naive patient	Recent paroxysmal AF without underlying cardiac involvement
Efficiency in maintaining rhythm	Very effective	Not very effective
Recurrence of AF	Less common	Common
FA load	Weak	Important
Recurrence of AF	Decreased	Increased
AF and heart failure	Improvement in LVEF	Alteration of LVEF
Complications	Collateral damage	Pro arrhythmia Negative inotropic effects Adverse effects of AARs

Complications of cardioversion

Thromboembolic complications: ECV and PCV present the same risk of thromboembolic events. The incidence of these events after cardioversion in non-anticoagulated AF patients is significantly high (2%) compared to those receiving Vitamin K Antagonists (VKA) (0.33%) (6.36).

A recent study demonstrated that the rate of thromboembolic events is low in patients placed on VKA within 30 days following cardioversion (0.28%) compared to those who did not receive anticoagulation (1.1%), this study is supported by Gallagher et al, who reported that unanticoagulated patients or those with inadequate anticoagulation appear to have a thromboembolic event rate of approximately 1%.

The incidence of thromboembolic events after ECV of AF was analyzed by Berger and Schweitzer, almost all thromboembolic events occur within 10 days after the procedure. Hence the recommendation of anticoagulation up to 4 weeks after cardioversion. In patients with AF lasting <48 hours, the rate of thromboembolic events in the absence of anticoagulation is approximately 0.7%, it increases with the CHA 2 DS 2-VASc score.

These thromboembolic events can occur after successful cardioversion by migration of the pre-existing left atrial thrombus in 4% of cases with non-anticoagulated AF and less than 48 hours. It should be noted that the absence of thrombus on TEE before cardioversion does not guarantee safe cardioversion, because the restoration of sinus rhythm results in a drop in left atrial blood flow velocity and an accentuation of atrial stasis favoring the formation of new thrombus and predisposes to embolization.

This study supports the current recommendation that these patients need effective anticoagulation before cardioversion followed by long-term oral anticoagulation. Concerning anticoagulated patients, there is no difference in thromboembolic risk between AF>48 hours or of unknown duration compared to AF<48 hours, however the rate of thromboembolic events is respectively 0.41% and 0.61% in patients on DOACs and VKAs [18].

Rhythmic complications: Bradycardia is a rare complication (0.9% of cases), generally benign after the ECV of recent onset AF, but it must be taken into account particularly in elderly patients and women, contrary to expectations, a ventricular cadence Slow or slow intake of medications such as beta-blockers and digoxin were not associated with an increased risk of asystole or brady arrhythmia.

Bradycardia after cardioversion can be treated with permanent pacemaker implantation, thereby reducing the incidence of AF by improving sinus node function. The incidence of bradyarrhythmias after cardioversion of persistent AF ranged from 0.8 to 1.5%, suggesting that the longer duration of AF may increase episodes of bradycardia after cardioversion.

Other rhythmic complications may be observed after ECV and are self-limiting or require surgery (VF due to inappropriate timing of shock, tachycardias, transient ST segment elevation).

Recurrence of AF: Recurrence of AF occurred in almost 60% of cases within 3 to 6 months, especially within the first 2 months. Many potential predictors such as age, underlying cardiovascular disease, duration of AF, inflammatory markers and Left Atrial (LA) size may drive AF recurrence [19].

Recent studies have proven that Left Atrial Volume Index (LAVI) was stronger than left atrial dimension in predicting AF recurrence after ECV. Wang said that IVAG was higher in patients with AF recurrence after conversion. A similar statement was suggested by Marchese et al., as well as Akdemir et al., who concluded that a larger IVAG before ECV, as a more precise measure than LA diameter, was strongly associated with higher risks of AF recurrence.

Atrial size and particularly IVAG could reflect the macroscopic aspect of remodeling responsible for numerous structural, functional, electrical, metabolic and neurohormonal consequences. Determining an irreversible threshold for atrial remodeling in AF can be difficult but achievable.

The IVAG measurement could be a useful method in the selection of AF patients for ECV. Despite the evidence from the previously mentioned studies, the latest guidelines for the management of AF have not yet included IVAG in the echocardiographic examination.

Immediate recurrences of persistent AF may be linked to the hyper vulnerability of the instantaneous post-shock, then to atrial dizziness. These recurrences can be prevented by ibutilide, sodium inhibitors and probably by sotalol and amiodarone. They can be further reduced by adding verapamil to class I or III AAR. And reapplying an immediate shock.

Subacute recurrences are secondary to nonuniform reverse electrical remodeling that increases electrical instability of the atria. These recurrences frequently occur over a period of 1 to 2 weeks. They can be avoided by combining AARs with an angiotensin receptor antagonist or verapamil. Beta-blockers alone can also reduce them.

Late recurrences are often aborted by single AAR or ECV in patients at low risk of recurrence and by catheter removal if the risk of recurrence is high (Figure 2) [20,21].

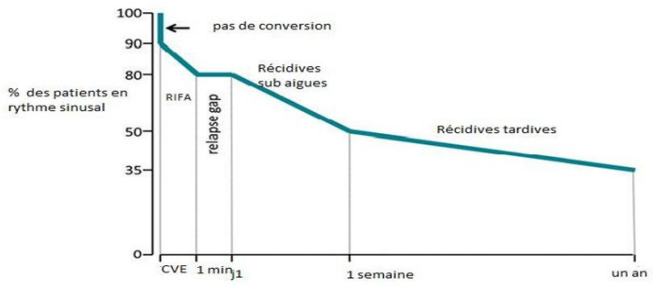

Figure 2: Recurrence after ECV of persistent AF: RIFA, immediate recurrence of atrial fibrillation.

CONCLUSION

Electrical cardioversion is an effective strategy for rhythm control in AF, its effectiveness depends on the waveform, high shock energy, manual pressure and positioning of the pads. This procedure leads in particular to thromboembolic complications, hence the need to administer anticoagulants before the procedure to optimize the safety of the procedure.

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