In this experiment, a stimulus is near the refractory period. This was illustrated in a study by Wijffels entitled Atrial Fibrillation Begets Atrial Fibrillation [1]. In this experiment, a single extrastimulus applied to the right atrium of goats did not induce atrial fibrillation (AF) when applied at the refractory period (127 msec).

Using pacemaker techniques, atrial fibrillation was induced for six hours and an extrastimulus was reapplied. The atrial refractory period was shortened (104 msec) and short runs of atrial fibrillation were induced. With longer inductions of pacemaker-induced atrial fibrillation, the atrial refractory period became shorter and induced atrial fibrillation lasted longer. The authors concluded that atrial fibrillation results in electrophysiologic changes of a shorter refractory period which promote the maintenance of atrial fibrillation. If sinus rhythm is maintained for a week, the electrophysiologic changes return to normal. These results make electrical cardioversion important in the management of atrial fibrillation [2].

The use of electrical cardioversion to treat arrhythmias dates back to ancient times. It was first performed by Zoll in 1962 [3].

INDICATION FOR CARDIOVERSION

Broadly, cardioversion should be considered for two populations of patients: those who are symptomatic with AF and those who present with AF for the first time. Patients who have symptomatic AF can have severe enough symptoms, such as severely decompensated heart failure, hypotension, uncontrolled ischemia, or angina, to mandate urgent cardioversion. Other patients with AF may have less severe symptoms, such as palpitations, fatigue, lightheadedness, and exertional dyspnea. Regardless of the degree of severity, any symptoms caused by atrial fibrillation warrant consideration of cardioversion as a management option.

ANTICOAGULATION

For AF episodes lasting less than 48 hours, the likelihood of thrombus formation and subsequent embolization after cardioversion is low. As such anticoagulation is not recommended routinely for patients who have episodes of duration less than 48 hours [4]. Neither pre- nor post-cardioversion anticoagulation is recommended for these short duration episodes.

Symptoms are generally not reliable as a marker of the presence or absence of AF. As such, in the absence of electrocardiographic evidence of the true onset of an episode of AF, it is most prudent to assume that the episode has been going on for more than 48 hours.

In AF lasting more than 48 hours, the risk for a thromboembolic event post cardioversion can be as high as 5% [5]. As such, the goals of pericardioversion anticoagulation for AF are to minimize the likelihood of a thrombus at the time of cardioversion and to prevent the formation of a new thrombus in the postcardioversion phase.

Two strategies may be used:

1. Empiric anticoagulation for three weeks with vitamin K with INR of 2 to 3. In one study with INR > 2.5 the risk of an embolic event was zero percent under those conditions [6].

2. Therapeutically anticoagulate with heparin and perform a TEE guided cardioversion.

In one study low molecular weight heparin was equivalent to unfractionated heparin in the setting of atrial fibrillation [7].

Given the delay of up to four weeks for recovery of atrial mechanical function post-cardioversion, patients should at least undergo four weeks of anticoagulation [4]. Further anticoagulation follows the classical recommendations.

CARDIOVERSION

Preparation of the patient

Patients should receive a deep sedation. Short acting drugs such as midazolam, fentanyl, and propofol, should be used in NPO (nothing per os) state to allow for same day discharge. In some cases general anesthesia may be indicated. Even in case of emergent cardioversion in cases of hypotension, heart failure or angina, some sedation is desirable if circumstances allow.

Electrodes

Anteroposterior versus anterolateral position:

Two studies showed no effect of pad or paddle place-
ment on cardioversion success in AF [8-9].

One study also showed that an increase in pad size did not affect the success of cardioversion in AF [9].

Shock
Currently, the evidence favors the use of biphasic external defibrillators for AF cardioversion compared to monophasic defibrillators. In fact, at equal energy the biphasic shock is associated with significantly less dermal energy than monophasic shock. With lower energies the biphasic shock is way more effective. At maximal energies both shocks may be as effective but with more dermal injury with the monophasic shock [9].

To avoid shock delivery during the vulnerable phase of the cardiac cycle (“shock on T”) and subsequent ventricular fibrillation, the synchronized mode should be activated and the appropriate sensing of the R wave should be ensured, with the verification of the synchronized signal on the R wave on the defibrillator screen.

Energy
While low energy shocks (25 to 50 joules biphasic or 100 joules monophasic) are very effective in cases of atrial flutter, atrial fibrillation usually requires near maximal, or maximal energy shocks. A good choice may be to start with maximal energy for every cardioversion for atrial fibrillation. Going with a strategy of low energy shocks with progressive increments might delay the procedure, and frustrate the team. When tansthoracic impedance is elevated i.e. obesity, emphysema and asthma, a 10 to 15 Kg weight on the paddles or the pads may decrease the impedance.

Delivery of the shock during the expiratory phase may also decrease the impedance.

Special situations
1. Implanted devices
   Anteroposterior position seems to lower the risk of injury to the device or to the patient in case external defibrillation is decided for atrial fibrillation [4]. In patients who have intracardiac defibrillators, cardioversion may be achieved with a commanded internal shock delivered through the device. For patients with atrial flutter, device delivered antitachycardia pacing should be attempted. This does not require sedation.

2. Pregnancy
   Cardioversion of AF during pregnancy should follow the same rules applied to the general population.

3. Internal cardioversion via intracardiac catheters
   This modality is performed in case external cardioversion fails.

Failure of cardioversion of atrial fibrillation:
It is very important to differentiate between failure to cardiovert atrial fibrillation that is related mainly to inability to deliver appropriate energy (Monophasic shock, high impedance, etc.), and immediate recurrence defined as recurrence of AF after at least one sinus beat. The immediate recurrence means that the energy was delivered appropriately but the substrate is prone for recurrence.

Left atrial enlargement and the presence of organic heart disease especially in the presence of left ventricular dysfunction or systemic diseases are the main reasons for IRAF (immediate recurrence of atrial fibrillation) [10]. Pharmacologically facilitated (pretreatment with flecainide or amiodarone) repeated cardioversion is indicated for IRAF [11].

For true failed cardioversion it is very likely that pretreatment with antiarrhythmics would be of no help.

COMPLICATIONS

DC cardioversion for atrial fibrillation is usually performed on ambulatory patients, and every measure should be taken to prevent these complications that fall into three categories.

1. Risk associated with sedation
   Problems associated with sedation can escalate fast into a very bad outcome, and we usually recommend the formation of a team in every institution to administer cardioversion. The team can consist of the cardiologist, an anesthesiologist, and an expert RN. The fact the same team performs all the cardioversions and use the same protocol on all patients may prevent serious complications.

2. Thromboembolic events
   Appropriate anticoagulation is key to prevent this complication as discussed earlier [6, 11]

3. Post-cardioversion arrhythmias
   Severe bradycardia leading to torsades is the most serious arrhythmia which may occur while performing a cardioversion. The patient should be informed and the cardiac catheterization laboratory make sure the set up is ready for transvenous pacing [12].

CONCLUSION

Over 60 years of experience have significantly improved this technique and made it safer to administer. It is however associated with rare but serious complications.

Specialized teams applying strict anticoagulation rules with standard non variable sedation protocols is essential to prevent the complications.

REFERENCES


