Clinical Investigations

Successful External Cardioversion of Atrial Fibrillation in Patients Referred to an Electrophysiologist for Internal Cardioversion

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Summary

Background: Internal cardioversion of atrial fibrillation with direct current energy has become an increasingly employed technique for patients who fail external cardioversion.

Hypothesis: The purpose of this study was to determine whether internal cardioversion could be avoided by careful attention to cardioversion technique in a group of patients referred specifically for internal cardioversion after failed external cardioversion by community cardiologists.

Methods: We performed external cardioversion utilizing two operators applying significant pressure to the thorax with up to 360 J prior to the planned internal cardioversion in 20 patients referred for internal cardioversion after failed attempts at external cardioversion.

Results: Sixteen patients (80%) were successfully cardioverted and avoided the risk, inconvenience, and cost of internal cardioversion.

Conclusion: External cardioversion with significant anterior paddle pressure by two operators can decrease the need for internal cardioversion in a significant portion of patients referred to electrophysiologists for internal cardioversion and should be considered prior to an invasive procedure.

Key words: external cardioversion, atrial fibrillation

Introduction

Atrial fibrillation in obese patients and patients with large thoracic cavities may be difficult to cardiovert to sinus rhythm using conventional external cardioversion techniques.¹ Internal cardioversion of atrial fibrillation with direct current energy has become an increasingly employed technique for patients who fail external cardioversion. Up to 20 joules (J) of energy can be synchronously delivered between multipolar electrode catheters placed along the lateral wall of the right atrium and into the coronary sinus in order to restore sinus rhythm. The success rates of this procedure are reported to approach 90% even after failed external cardioversion.^{2,3} However, this invasive procedure is associated with additional risks, cost, and inconvenience. Patients may be instructed to withhold oral anticoagulation for a few days prior to the procedure that requires at least two central venous cannulations. Heparin is administered at the time of cardioversion and occasionally must be administered intravenously for several days until the prothrombin time increases to a therapeutic level. Hospitalization costs and the use of specialized catheters and laboratory time significantly add to the expense of this procedure. The addition of cardioactive drugs such as atropine and ibutilide prior to cardioversion has recently been shown to increase the success rates of external cardioversion in patients who failed initial attempts.^{4–6} Although the study by Li *et al.* demonstrated no evidence of proarrhythmia possibly secondary to the empiric administration of intravenous magnesium, 6% of the procedures in the study by Oral *et al.* were complicated by torsades de pointes which required defibrillation in two of the three patients.^{5,6} Requiring an external shock to terminate torsades de pointes is of special concern in a group of patients who failed external cardioversion for atrial fibrillation, an arrhythmia possibly requiring a lower conversion energy requirement. The purpose of this study was to determine whether internal cardioversion could be avoided by careful attention to cardioversion technique in a group of patients referred specifically for internal cardioversion after failed external cardioversion by community cardiologists.

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Methods

Consecutive patients were referred for internal cardioversion following multiple failed attempts at external direct current cardioversion by community cardiologists. Patients arrived in the electrophysiology laboratory in a fasting, postabsorptive state and were actually continued on their oral anticoagulation. Prothrombin times were checked to ensure levels were therapeutic. Prior to undergoing the planned internal cardioversion, each patient underwent an additional attempt at external cardioversion by one of the investigators. Patients were sedated using intravenous propofol. Gelatinous pads (Defib-Pads 2346N, $4\frac{1}{2} \times 6$ ", 3M, St. Paul, Minn., USA) were applied to the chest wall in a standard right parasternal-left apical position. To maximize pressure during cardioversion, two different operators firmly applied hand-held defibrillator paddles over the pads. The amount of energy of the first synchronized shock varied between 200 and 360 J and was left to the individual investigator. Patients who failed two 360 J shocks proceeded to internal cardioversion. Internal cardioversion was performed with a decapolar catheter (5 mm electrodes, 2 mm spacing, Elacath, Rahway, N.J., USA) placed in the coronary sinus and another against the right atrial lateral wall. Internal shock delivery utilized a biphasic waveform generated from a Ventritex HVS-0200 (Ventritex, Inc., Sunnyvale, Calif., USA) with maximum energy of 20 J. A standard quadripolar catheter was placed into the ventricle for shock synchronization and backup pacing.

Results

Patient Population

The study cohort included 20 patients (19 men, 1 woman) with a mean age of 54.1 ± 12.0 years. Their mean weight was 120.3 ± 29.6 kg and mean body mass index was 37.0 ± 9.0 kg/m². Eleven patients (55%) had structurally abnormal hearts; five patients had ischemic cardiomyopathy. Two patients had cardiomyopathy secondary to valvular heart disease, and two had hypertensive heart disease. One patient had a nonischemic dilated cardiomyopathy, while one patient had hypertrophic obstructive cardiomyopathy and had previously undergone septal myotomy and myectomy. Of the entire cohort, four patients had obstructive sleep apnea but none was diagnosed with chronic obstructive lung disease.

Arrhythmia History

The mean duration of atrial fibrillation was 15.6 ± 11.5 weeks. All patients were taking antiarrhythmic drugs at the time of their referral to our institution. Fourteen patients were taking amiodarone, 3 sotalol, 2 flecainide, and 1 patient was taking procainamide. All of these medications were the same antiarrhythmic drugs as those the patients were taking during their final attempt at external cardioversion by the referring physician. The cardioversions were performed by 16 different

cardiologists and included at least one shock of 360 J in 19 of the 20 patients. One patient received a maximum of 300 J, as the referring cardiologist did not even attempt a 360 J shock. Eight of the 20 patients had previously undergone one trial of cardioversion (consisting of at least two shock deliveries) prior to their referral, while 7 patients had two separate trials, and 5 patients experienced three or more separate attempts at cardioversion prior to referral to our institution.

Cardioversion Results

With the two-operator technique and careful attention to cardioversion technique, 16 of the 20 patients (80%) were successfully cardioverted with external application of direct current shocks and did not require internal cardioversion. The energy of the successful shocks was 200 J for 1 patient, 300 J for 2 patients, and 360 J for 13 patients. Of the four patients who failed our attempts at external cardioversion, internal cardioversion was successful in two (5 J and 10 J), and two patients failed to convert to sinus rhythm with internal cardioversion (maximum 10 J and 16 J, respectively).

Patient Follow-Up

Long-term follow-up information was obtained for 14 of the 16 patients successfully cardioverted externally. One patient had a recurrence of atrial fibrillation at 24 h post procedure. He remains in chronic atrial fibrillation. The other 13 patients remain in sinus rhythm during the mean follow-up of 9.4 ± 7.7 months. Four of these patients experienced recurrent atrial fibrillation. One patient spontaneously converted to sinus rhythm; two were successfully externally cardioverted again; and one patient had two recurrences both successfully performed externally with the two-operator technique. At the time of follow-up, all 13 patients in sinus rhythm who were successfully externally converted were taking antiarrhythmic drugs. Nine patients were taking amiodarone, two flecainide, and two sotalol. These were the same antiarrhythmic drugs as those the patients were taking during the successful external cardioversion, except for one patient whose medication was changed from sotalol to amiodarone because of side effects.

Discussion

Success rates for transthoracic electrical cardioversion of atrial fibrillation have been excellent since early descriptions of this procedure. Lown *et al.* reported a series of 11 successful cardioversions of atrial fibrillation in 12 patients almost four decades ago.⁷ Seven of these patients had atrial fibrillation for longer than 1 year, and two of these for 5 years. Despite the years of experience with direct current cardioversion and the high success rate of the procedure, there continues to be controversy about the optimal sites of energy application and the amount of energy applied to the chest wall.⁸ The approach of a synchronized 200 J shock applied to the chest via anterior paddles or anterioposterior patch electrodes remains a standard.⁹

However, recent data suggest that an initial energy of 360 J is significantly more effective and results in less total cumulative energy requirement than starting at either 100 J or 200 J.¹⁰

Innovations in the field of electrophysiology have further increased success rates of external cardioversion. High-output defibrillators, sequential shocks,¹¹ biphasic waveforms,¹² and pretreatment with pharmacologic agents have all contributed to the effectiveness of this procedure, especially in patients with large thoracic cavities and those with longer episodes of atrial fibrillation.

Pretreatment with antiarrhythmic drugs as well as autonomically active compounds have been shown to be efficacious in further increasing success rates of external cardioversion. Transthoracic electrical cardioversion was effective in all 50 patients pretreated with intravenous ibutilide, compared with only 36 of 50 patients not given the drug prior to cardioversion.⁶ A second study reported successful cardioversion after administration of 1 to 2 mg of intravenous ibutilide to 11 of 12 patients who failed external cardioversion.⁵ Autonomically active compounds such as atropine have also been shown to increase external cardioversion results. In a series of 22 patients refractory to standard external cardioversion, 9 were successfully converted after the administration of 600 mcg of intravenous atropine.⁴ However, the administration of these drugs is not without complications. Acute intravenous administration of antiarrhythmic drugs can cause torsades de pointes arrhythmias, as 3% in the series reported by Oral *et al.* required defibrillation for sustained polymorphic ventricular tachycardias.⁵

The goal of restoring sinus rhythm in order to increase cardiac output, alleviate patients' symptoms, and decrease the rate of embolic complications has stimulated clinicians to strive for even higher success rates with the technique of internal cardioversion. The application of energy between catheters positioned inside the right atrium and coronary sinus or right ventricular outflow tract is now commonly employed in patients who fail external cardioversion. Success rates of up to 90% have been reported. Yet, this invasive procedure is hindered by the associated risks and costs of intravascular catheterization, and anticoagulation issues often require several days of in-patient hospital stay.

Our study demonstrates that external cardioversion with significant anterior paddle pressure by two operators can decrease the need for internal cardioversion in a significant portion of patients referred to electrophysiologists for internal cardioversion. External cardioversion with meticulous attention to electrode position and pressure should be considered prior to an invasive procedure or administration of a cardioactive drug. Although the exact details of the failed cardioversion attempts performed by the community cardiologists were not examined in this study and may vary significantly, the intention of this study was not to make a formal comparison of one specific method with another. Instead, it is meant to raise awareness among physicians performing external cardiover-

sions that careful attention to minimizing intrathoracic resistance by applying pressure in the standard anterior chest positions should increase their success rates. This study is also meant to raise awareness for cardiologists who perform internal cardioversions, as many patients referred for this procedure may be successfully cardioverted externally. In addition, wide-scale educational programs emphasizing the technical details of the proper cardioversion technique may be beneficial. Internal cardioversions may not be required in many patients, and an attempt at external cardioversion with careful attention to detail may avoid unnecessary cost, risk, and inconvenience to the patient.

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