

CONVERSION OF ATRIAL FIBRILLATION BY DIRECT CURRENT COUNTER SHOCK

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The adverse effects of atrial fibrillation on the circulation are well known. It reduces cardiac output and stroke volume (Kory and Meneely, 1951; Broch and Müller, 1957), may lead to cardiac dilatation and failure (Phillips and Levine, 1949), and is associated with a high risk of systemic embolization (Sokolow, 1951; Fraser and Turner, 1955).

Unfortunately, attempts to restore sinus rhythm with drug therapy are often unsuccessful and carry a definite hazard. Thus the mortality from quinidine conversion of atrial fibrillation still varies from 1 per cent (Yount, Rosenblum, and McMillan, 1952) to 3 per cent (Hay, 1924; Askey, 1946), and morbidity from quinidine toxicity is much higher (Kohn and Levine, 1935; Thompson, 1956; Rokseth and Storstein, 1963).

The use of alternating current applied to the chest wall for the abolition of supraventricular arrhythmias was limited by the risk of ventricular fibrillation (Zoll *et al.*, 1956; Paul and Miller, 1962).

Gurvich and Yuniev (1947) were the first to draw attention to the effectiveness of capacitor discharge in defibrillating the heart, though the technique was first used by Prevost and Battelli (1899). Their results, however, were not confirmed by Guyton and Satterfield (1951) or Kouwenhoven and Milnor (1954).

Lown *et al.* (1962b) showed that in dogs direct current capacitor discharge was superior to alternating current in abolishing ventricular fibrillation. He also showed that the capacitor discharge of 2.5 millisecond duration, synchronized to avoid the vulnerable period at the apex of the T wave, was effective in the abolition of atrial fibrillation without the risk of ventricular fibrillation (Lown, Amarasingham, and Neuman, 1962a).

Further clinical studies by Lown *et al.* (1963), Killip (1963), and Oram *et al.* (1963) have confirmed the effectiveness and safety of this procedure. The results of direct current capacitor discharge in attempted conversion of atrial fibrillation in 83 patients are presented here.

SUBJECTS AND METHOD

There were 75 patients with rheumatic heart disease, 6 with a history of thyrotoxicosis, and 2 with myocardial ischaemia. Their ages varied from 25 to 65 with an average of 46.2 years. There were 54 women and 29 men. Four patients had normal exercise tolerance, 67 were in grade 2, and 12 were in grade 3 disability as defined by the New York Heart Association (1953). There were 51 patients who had undergone previous mitral valvotomy, and of these 17 had more than one operation. The average time interval between attempted conversion and the last valvotomy was 2.5 years. The duration of atrial fibrillation varied from 1 month to 16 years with an average of 46.1 months. Quinidine conversion was not attempted in any of these patients immediately before D.C. conversion. Quinidine conversion had, however, been attempted without success in four patients, 4 to 6 years before D.C. shock conversion. D.C. shock was effective in three of the four.

A direct current condenser discharge of 2.5 millisecond duration with energy levels between 100–400 watt

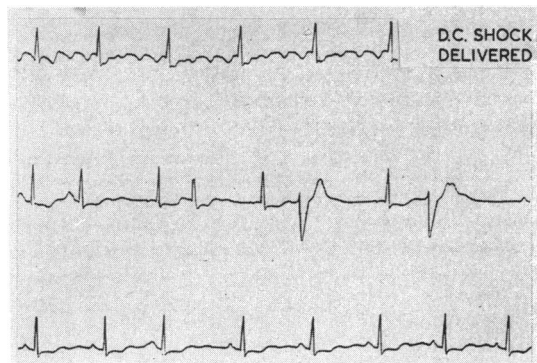


FIG. 1.—Electrocardiogram showing multifocal extrasystoles immediately after D.C. shock.

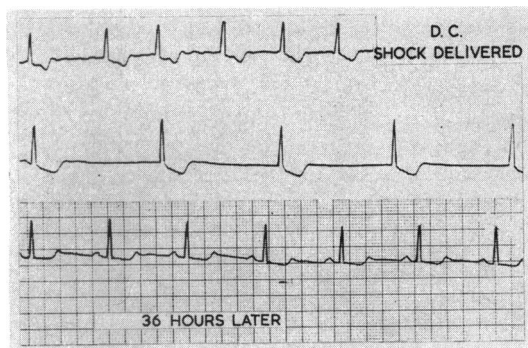


FIG. 2.—Electrocardiogram showing slow nodal rhythm following D.C. shock. A few hours later patient had Stokes-Adams attacks.

seconds (3000–7000 volts) was applied across the chest between electrodes placed at the second intercostal space just to the right of the sternum and in the posterior axillary line at the level of the apex, the negative electrode being in the axilla. A synchronizer ensured that the discharge was delivered 0.02 second after the R wave of the electrocardiogram.

Anæsthesia when required was usually limited to methohexitone sodium (50–100 mg.), a short-acting barbiturate, producing loss of consciousness of less than four minutes. When the required voltage was low (3000 volts, 100 watt seconds) anæsthesia was not necessary. None of the patients were treated with anticoagulants.

Serum glutamic oxalic transaminase (S.G.O.T.) estimations were obtained after the direct current shock in the first 34 patients. All successful conversions were given quinidine sulphate gr. 5 four times a day and were maintained on this dosage.

RESULTS

Sixty-five of the 83 patients (78%) were converted to sinus rhythm. Of these, 37 (57%) required only one shock. Most patients in the post-thyrototoxic and ischæmic groups were converted after one shock of 100 watt second. The average duration of atrial fibrillation was 35.7 months in patients who were converted and 81 months in those in whom sinus rhythm was not restored.

Multifocal extrasystoles were not infrequently seen immediately after the shock but normal sinus rhythm spontaneously supervened after one to two minutes (Fig. 1).

On three occasions following defibrillation the sinus pacemaker failed to become established and nodal rhythm appeared. Sinus rhythm was established in two of these patients following atropine administration. In the other patient slow nodal rhythm (rate 45) continued. Twelve hours after defibrillation two Stokes-Adams attacks occurred and repeated injections of atropine were required to keep the rate around 55 a minute. Since over-digitalization seemed likely, large doses of oral potassium chloride were given and reversion to sinus rhythm occurred after two days (Fig. 2).

Electrocardiographic evidence of over-digitalization was seen in 20 per cent of successful conversions and in 83 per cent of those in whom conversion was not achieved. Over-digitalization was taken to be present when two of the three following features, i.e. bradycardia, frequent ventricular extrasystoles, and marked S-T depression, were seen in a tracing taken before conversion.

Three patients showed an unexplained rise in temperature to 102°–103°F. (39°C.) which settled in 24 hours, but the erythrocyte sedimentation rate, white cell count, and S.G.O.T. remained normal. All S.G.O.T. estimations were normal. No embolic complications were seen following conversion.

Ten patients (15%) reverted to atrial fibrillation within one week. The rest have been maintained in sinus rhythm, the longest follow-up being 3½ months.

DISCUSSION

The safety of direct current conversion is confirmed in this study. The use of anticoagulants before conversion appears to be unnecessary. This view is supported by the work of Killip (1963), who found no difference in the incidence of embolism between patients treated with anticoagulants and those not so treated. It is perhaps too early to say yet whether preliminary anticoagulant treatment should or should not be given.

No patient became hypotensive following conversion. This may be due to minimal anaesthesia or to the fact that scoline was not used. The discomfort produced by direct current discharge at 100 watt seconds (3000 volts) is minimal and patients who convert at this level do not require anaesthesia. It seems possible in many patients to predict the energy level required for conversion. Thus patients with post-thyrotoxic atrial fibrillation do not often require more than 100 watt seconds. Patients with atrial fibrillation of recent origin associated with rheumatic heart disease will usually be converted at this level.

As expected the duration of atrial fibrillation is inversely related to success rate of conversion. This correlation however is true only for patients with rheumatic heart disease.

Failure of the sinus pacemaker to become established in three patients is of interest. Killip (1963) described the appearance of slow nodal rhythm after defibrillation of the atria. He suggested that the cause might be a "dead" sinus node and dealt with the situation by potassium depletion to achieve a return to atrial fibrillation. Our experience suggests that over-digitalization may be responsible for failure of the sinus pacemaker since the administration of atropine in two patients and potassium chloride in one restored sinus rhythm.

The chances of successful conversion are less in patients who have been over-digitalized. If there is evidence of over-digitalization it seems advisable to stop the digitalis one week before conversion and when over-digitalization is severe to administer potassium chloride.

SUMMARY

Direct current condenser discharge has been used in 83 patients with atrial fibrillation in an attempt to abolish the arrhythmia. Sinus rhythm was established in 78 per cent. Anticoagulants were not used and no embolic phenomena were encountered. Anaesthesia is not required with low voltages. The adverse effects of over-digitalization before conversion are indicated.

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ADDENDUM

Conversion has now (October 1, 1964) been attempted without complications in a further 103 patients with an over-all conversion rate of 78·9 per cent.