ELECTIVE ELECTROCONVERSION OF CARDIAC ARRHYTHMIAS

By Low Lip Ping and Charles Toh Chai Soon

SYNOPSIS

45 patients with 61 episodes of cardiac arrhythmias were treated with synchronised direct current countershock. The immediate successful conversion rates were 78.3% in atrial fibrillation, 100% in atrial flutter, 85.7% in supraventricular tachycardia and 100% in ventricular tachycardia.

There was no immediate mortality and few serious side effects. One patient developed ventricular tachycardia which was immediately converted to sinus rhythm with a further shock of higher energy setting.

Although the immediate conversion rate of atrial fibrillation in this series was fair (78.3), the 12 months' follow up results were disappointing.

Atrial flutter gave the best results with synchronised D.C. shock. Moreover, the energy required is the lowest, generally below 100 watt-seconds.

With supraventricular tachycardia and ventricular tachycardia relapses after successful reversion do occur but, unlike atrial fibrillation, they are more easily reverted again, either with drugs or repeated synchronised D.C. shock.

The place, advantages, and possible complications of electroconversion in the treatment of cardiac arrhythmias are reviewed.

In 1932 Kouwenhoven[1] and his colleagues experimented with various electrical discharge circuits for the electrical defibrillation of ventricular fibrillation. The subsequent extensive work of Kouwenhoven encouraged the general acceptance of electrical "countershock" as a therapeutic tool.

Beck *et al*[2] in 1947 successfully defibrillated a patient who recovered completely.

In 1961, Lown and his colleagues[3] first demonstrated the elective use of A.C. (alternating current) shock for treating arrhythmias other than ventricular fibrillation, when they successfully terminated an episode of ventricular tachycardia which had been resistant to antiarrhythmic drugs, in a patient with coronary artery disease. Lown[4] further showed that an underdamped impulse from a D.C. Capacitor released through an inductance was the safest and most effective for electrical defibrillation. The introduction of a synchroniser in the circuit which triggers the discharge to avoid the vulnerable period at the apex of the T wave of the electrocardiogram has increased the safety of the procedure, at least in theory.

Department of Medicine (Medical Unit II) University of Singapore.

LOW LIP PING, M.B., B.S., M.R.A.C.P., A.M., Lecturer.

CHARLES TOH CHAI SOON, A.M., M.B., B.S., M.R.C.P., M.R.A.C.P., F.A.C.C., Associate Professor.

Subsequent reports[5,6,7,8,9,10] confirmed the effectiveness of D.C. Countershock in the treatment of atrial and ventricular arrhythmias.

This report describes our experience of electroconversion of 61 episodes of cardiac arrhythmias occurring in 45 patients.

SUBJECTS

The 45 patients consisted of 25 with rheumatic heart disease, 7 with ischaemic heart disease, 7 with "lone" arrhythmias and a miscellaneous group with one each of atrial septal defect, cor pulmonale and two with thyrotoxicosis. There were 30 males and 15 females. Of the 25 patients with rheumatic heart disease, 24 had mitral valvotomy for mitral stenosis. 13 of the female patients had rheumatic heart disease. The mean ages for the rheumatic, ischaemic, "lone" arrhythmia and miscellaneous groups were 34·0, 57·9, 39·9 and 47·3 years respectively (Table I).

There were 25 patients with 21 episodes of atrial fibrillation, of which 20 patients had rheumatic heart disease; 8 patients with 14 episodes of atrial flutter; 5 patients with 7 episodes of supraventricular tachycardia and 7 patients with 12 episodes of ventricular tachycardia (Table II).

D.C. Countershock administered as emergency treatment following resuscitation of cardiac arrest, as for ventricular fibrillation or tachycardia in acute myocardial infarction, is not included in this report.

TABLE I

AGE, SEX AND HEART DISEASE

Heart Disease	Total No. Patients	Sex		Age	
		M	F	Range	Mean
Rheumatic Heart Disease	25	12	13	17-52	34·0
Post-Operative	23*	10*	13	—	—
Not Operated	3*	3*	—	—	—
Ischaemic Heart Disease	7	7	—	56-60	57·9
Idiopathic	7	7	—	21-62	39·9
Miscellaneous	6	4	2	36-58	47·3
TOTAL	45	30	15	—	—

*One patient treated both before and after mitral valvotomy.

TABLE II

HEART DISEASE AND ARRHYTHMIA

Heart Disease	All Arrhythmias	Arrhythmias			
		A. Fib.	A. Flut.	S.V.T.	V.T.
Rheumatic Heart Disease	25	20	4	1	—
Ischaemic Heart Disease	7	2	1	—	4
Idiopathic	7	1	—	4	2
Miscellaneous:					
Thyrotoxicosis	2	2	—	—	—
Atrial Septal Defect	1	—	1	—	—
Cor Pulmonale	1	—	1	—	—
Cardiomyopathy	1	—	1	—	—
Hyperkalaemia	1	—	—	—	1
TOTAL	45	25	8	5	7

S.V.T. denotes Supraventricular Tachycardia. V.T. denotes Ventricular Tachycardia.

METHODS

Patients with atrial fibrillation or atrial flutter due to rheumatic heart disease received anticoagulants for a minimum of 10 days. Those who had undergone mitral valvotomy were treated only after the sixth post-operative week. Except in the first 5 patients treated, digitalis, when used, was stopped for at least 24 hours before, and resumed the day after the procedure.

Quinidine was administered for 24 hours before the procedure to all, except the first 8 patients, with atrial fibrillation or flutter due to rheumatic heart disease, and continued if electroconversion was successful. Because of increasing reports of serious ventricular arrhythmias and sudden death in patients given quinidine, this drug was later stopped in most of the patients. Generally, we do not now administer quinidine for more than a week after successful electroconversion.

Conversion to sinus rhythm with drugs was attempted in all patients with supraventricular and ventricular tachycardias before they were referred for electroconversion. A variety of drugs were used including digoxin, procaine amide, quinidine, antazoline and lignocaine.

Chest radiographs were taken in all patients. A 12-lead E.C.G. was recorded immediately before and after treatment. The E.C.G. was also monitored with an oscilloscope throughout the procedure and for at least 24 hours after. E.C.G. samples and blood pressure were recorded at hourly or more frequent intervals.

Intravenous thiopentone was used for anaesthesia in the first 10 patients. Subsequent patients were anaesthesized with intravenous propanidid ("Epontol") in an average dose of 200 mg. No premedication was administered.

Either one of two defibrillators was used to deliver a synchronised D.C. shock, viz. the Watson-Victor Cardiotrace Mk. II defibrillator, and the Corbin-Farnsworth DCXX defibrillator. The initial energy setting was either 40, 50 or 60 watt-seconds, or 80 or 100 watt-seconds (according to the defibrillator used), except for 2 patients who received 200 watt-seconds as the initial dose. If this was unsuccessful, further higher energy shocks in the order of 80 or 100, 200 and 400 watt-seconds were given until sinus rhythm ensued. The procedure was discontinued if sinus rhythm could not be established with 400 watt-seconds.

RESULTS

Sinus rhythm followed D.C. shock in 54 (88·5%) of 61 episodes of all arrhythmias treated (Table III).

Atrial Fibrillation

20 patients with rheumatic mitral stenosis, all of whom had mitral valvotomy, accounted for 23 of the 28 episodes of atrial fibrillation. Of the 23 episodes, 18 (78·3%) were successfully converted to sinus rhythm.

One patient with "lone" atrial fibrillation and two patients with thyrotoxicosis and one with ischaemic heart disease and atrial fibrillation were converted to sinus rhythm. The remaining patient with ischaemic heart disease failed to respond to D.C. shock.

16 episodes of atrial fibrillation were converted with 1 shock, 2 with 2 shocks, 3 with 3 shocks and only 1 required 4 shocks (Table IV).

The energy setting for successful conversion was 100 watt-seconds or less in 15 episodes, while only 3 episodes required the maximum of 400 watt-seconds for conversion.

The duration of atrial fibrillation, time of mitral valvotomy and amplitude of 'f' waves are shown in Tables V, VI and VII. Any significant influence these

TABLE III

IMMEDIATE SUCCESSFUL CONVERSION TO SINUS RHYTHM

Arrhythmia	Total No. of Episodes Treated	Successful Conversion	
		No.	%
Atrial Fibrillation	28	22	71·4
Atrial Flutter	14	14	100·0
Supraventricular Tachycardia	7	6	85·7
Ventricular Tachycardia	12	12	100·0
All Arrhythmias	61	54	88·5

TABLE IV

NO. OF SHOCKS REQUIRED AND ENERGY SETTING FOR SUCCESSFUL CONVERSION

Arrhythmia	No. of Shocks Required				Energy Setting of Successful Conversion Watt-second			
	1	2	3	4	40, 50 or 60	80 or 100	200	400
Atrial Fibrillation	16	2	3	1	4	11	4	3
Atrial Flutter	13	1	—	—	8	5	1	—
Supraventricular Tachycardia	6	—	—	—	3	3	—	—
Ventricular Tachycardia	10	2	—	—	2	7	1	2
TOTAL	45	5	3	1	17	26	6	5

TABLE V

DURATION OF ATRIAL FIBRILLATION (RHEUMATIC HEART DISEASE) BEFORE TREATMENT

	Duration of Atrial Fibrillation			Total
	< 6 mth.	6 mth. - 2 yr.	> 2 yr.	
No. of Episodes Treated	9	8	6	23
No. of Episodes Converted to Sinus Rhythm	8	7	3	18
Converted Episodes:				
Average Follow Up Duration	24·9 mth.	30·9 mth.	35·3 mth.	28·9 mth.
Average Duration in Sinus Rhythm	11·9 mth.	10·1 mth.	7·8 mth.	10·5 mth.
No. in Sinus Rhythm / No. Followed Up at 6 months	4/7	4/7	1/3	9/16
No. in Sinus Rhythm / No. Followed Up at 1 year	3/6	1/6	1/3	4/4

TABLE VI

RHEUMATIC HEART DISEASE (ATRIAL FIBRILLATION AND ATRIAL FLUTTER) TIME OF OPERATION BEFORE TREATMENT

	< 6 mth.	6 mth.- 1 yr.	1 yr.
No. of Episodes Treated	7	8	15
No. Converted to Sinus Rhythm	6	7	12

TABLE VII

ATRIAL FIBRILLATION: AMPLITUDE OF 'f' WAVES AND RESPONSE TO TREATMENT

	Amplitude of 'f' Waves		
	< 0.1 mV	0.1 - 0.2 mV	> 0.2 mV
No. of Episodes Treated	12	8	8
Successfully Converted	9	6	7

factors might have had on the chance of successful conversion could not be demonstrated with this small series.

The cardio-thoracic ratios (C.T.R.) on plain chest radiographs are shown in Table VIII. 10 out of 11 episodes of atrial fibrillation, in patients with C.T.R. of 54% or less, were successfully converted to sinus rhythm. Of 17 episodes in patients with C.T.R. more than 54%, 12 episodes were successfully converted.

Atrial Flutter

There were 8 patients with 14 episodes of atrial flutter. Of these, 4 patients had rheumatic mitral stenosis, one was treated before and after mitral valvotomy and one was not operated upon. The other 4 patients consisted of one each with congenital atrial septal defect, cardiomyopathy, ischaemic heart disease and cor pulmonale.

All 41 episodes were successfully converted, 13 with one shock, which was 40, 50 or 60 watt-seconds in 8 episodes, 80 or 100 watt-seconds in 5 episodes, and 200 watt-seconds in 1 episode (Table IV).

Supraventricular Tachycardia

There were 5 patients with 7 episodes of supraventricular tachycardia consisting of 1 patient with rheumatic heart disease with recurrence of rheu-

TABLE VIII

CARDIO-THORACIC RATIO AND SUCCESSFUL CONVERSION

Arrhythmia	Cardio-Thoracic Ratio					
	50%		50-54%		54%	
	Episodes Treated	Episodes Successfully Treated	Episodes Treated	Episodes Successfully Treated	Episodes Treated	Episodes Successfully Treated
Atrial Fibrillation	4	3	7	7	17	12
Atrial Flutter	—	—	5	5	9	9
Supraventricular Tachycardia	5	4	2	2	—	—
Ventricular Tachycardia	4	4	3	3	5	5
All Arrhythmias	13	11	17	17	31	26

matic fever, 4 patients with "lone" arrhythmias (including one with Wolff-Parkinson-White syndrome).

6 episodes (85·7%) were successfully converted. The only failure occurred in the patient with rheumatic heart disease. All episodes were converted with one shock. 3 episodes were converted with 40 or 50 watt-seconds and 3 with 80 or 100 watt-seconds (Table IV).

One patient with "lone" atrial tachycardia who did not respond to 1·4 mg. of Cediland, was converted to sinus rhythm with 50 watt-seconds, but reverted in 10 minutes. A further shock of 100 watt-seconds resulted in sinus rhythm which again persisted for only 10 minutes. He eventually responded to intravenous antazoline.

Ventricular Tachycardia

12 episodes of ventricular tachycardia occurred in 7 patients. Four patients had ischaemic heart disease, one had hyperkalaemia due to acute-on-chronic renal failure, and two were idiopathic "lone" arrhythmias.

12 episodes were successfully converted, 10 with 1 shock and 2 with 2 shocks. An energy setting of 40 or 50 watt-seconds was used in 2 episodes, 80 or 100 watt-seconds in 7 episodes, 200 watt-seconds in one episode, and 400 watt-seconds in 2 episodes.

2 of the episodes occurred in one patient over a period of 24 hours, and were both converted to sinus rhythm with a single shock of 50 watt-seconds. Following the second shock he remained in sinus rhythm until discharged from hospital (Fig. 4).

FOLLOW UP

Atrial Fibrillation (Fig. 1)

All 22 episodes successfully converted were followed up for one year. In this interval there were 16 reversions to atrial fibrillation—2 within 24 hours, 4 within one week, 4 each within one month, 3 months, and one year. Of 7 converted episodes, followed for more than 3 years, 2 remained in sinus rhythm, even after all drugs were withdrawn.

The duration of atrial fibrillation before treatment appeared to influence the duration of persistence in sinus rhythm (Table V). Thus, in patients with atrial fibrillation for six months or less, the average duration of sinus rhythm was 11·9 months, out of an average follow up of 24·9 months. In contrast, patients who had atrial fibrillation for more than 2 years, persisted in sinus rhythm for an average duration of only 7·8 months out of an average follow up of 35·3 months.

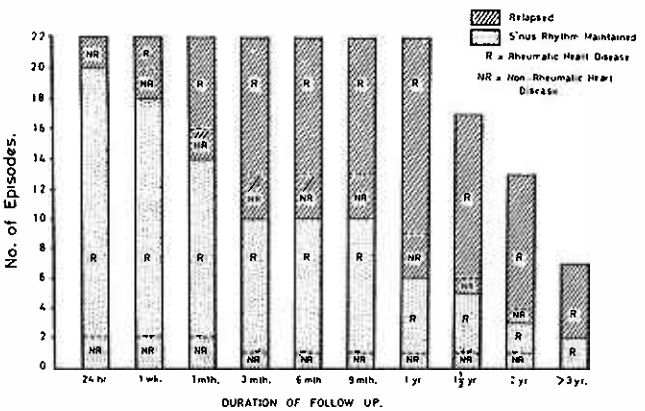

Fig. 1. Follow up of successful conversions: Atrial Fibrillation.

No influence on the persistence of sinus rhythm could be demonstrated with the amplitude of 'f' waves or cardiothoracic ratio.

Atrial Flutter (Fig. 2)

9 out of 14 episodes of atrial flutter converted remained in sinus rhythm for 3 months. Of the 8 episodes followed up for one and a half years, only 2 reverted. One of these occurred following mitral valvotomy in a patient whose atrial flutter was converted before the operation. This recurrence was also successfully treated with D.C. shock. 3 patients were still in sinus rhythm more than 3 years after treatment.

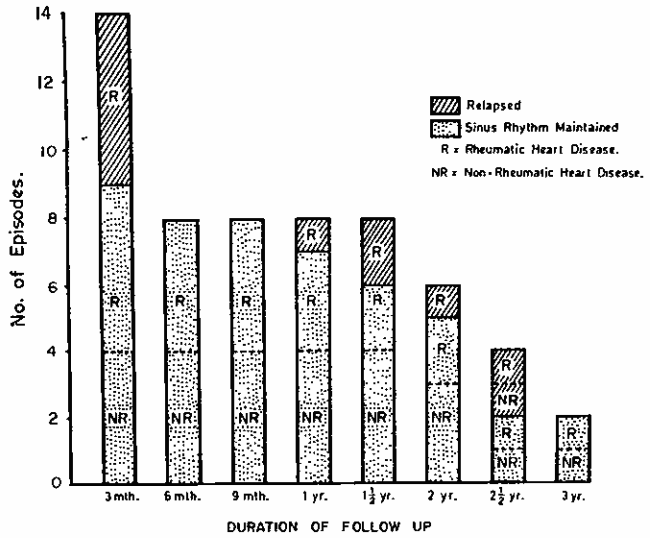

Fig. 2. Follow up of successful conversions: Atrial Flutter

Supraventricular Tachycardia (Fig. 3)

Of the 6 episodes of supraventricular tachycardia converted, 2 reverted within 24 hours and these occurred in the patient described above who eventually was treated successfully with intravenous antazoline. One other episode reverted within 3 months and another only after two and a half years. All were successfully treated again with D.C. shock.

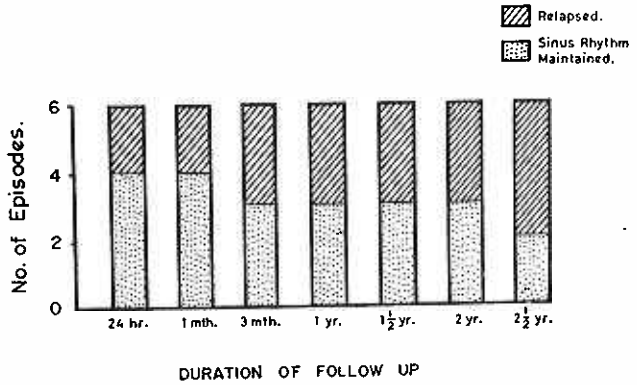

Fig. 3. Follow up of successful conversions: Supraventricular Tachycardia.

Ventricular Tachycardia (Fig. 4)

Of the 12 episodes of ventricular tachycardia converted to sinus rhythm, one reverted within 24 hours. Following a second D.C. shock, sinus rhythm persisted for 3 months after which the patient was lost to follow up.

In 2 patients ventricular tachycardia recurred twice, at intervals of 2 weeks and 5 days in one, and 17 days and two and a half months in the other. In both, relapses were successfully treated with D.C. shock; they remained thereafter in sinus rhythm for over 3 years but required quinidine maintenance.

In a third patient, following successful conversion the underlying hyperkalaemia was successfully treated with peritoneal dialysis. She remained in sinus rhythm, but died 4 months later of renal failure.

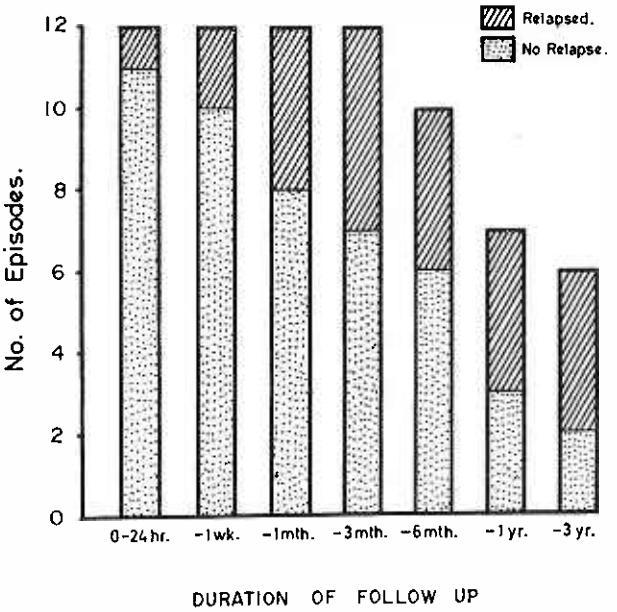

Fig. 4. Follow up of successful conversions: Ventricular Tachycardia.

COMPLICATIONS

Mortality—There was no mortality due to the procedure.

Anaesthesia—No serious complications due to anaesthesia, were encountered. In the dosages we employ, we have found intravenous propanidid to be both effective and safe.

Hypotension—Hypotension, defined as a systolic blood pressure of 80 mm. Hg. or less for one hour or longer, was not encountered.

Pulmonary Oedema—Pulmonary oedema was not detected clinically on any occasion. As few patients had chest radiographs in the immediate

post cardioversion period, the incidence of radiologically detected pulmonary oedema is not known; in any case, this is a rare complication usually associated with clinical signs.

Embolic Phenomenon—No episode of embolism, whether systemic or pulmonary was encountered.

Skin Burns—Erythema and superficial epidermal burns were common but never serious. These can be minimised by liberal application of electrode-jelly rubbed well into the skin to lower its electrical resistance.

E.C.G. Changes—Temporary E.C.G. changes, particularly rhythm disturbances, were common immediately after D.C. shock (Table IX). They occurred mainly in patients with mitral stenosis; this was probably due to the fact that most of these patients had received both digoxin and quinidine before cardioversion, although the former was omitted for at least 48 hours before the procedure.

TABLE IX

E.C.G. CHANGES FOLLOWING D.C. COUNTERSHOCK

	No. of Episodes
Atrial Ectopics	23
Nodal Ectopics	7
Ventricular Ectopics	8
Abnormal P Waves	7
Sinus Bradycardia	2
Intermittent Sino-Atrial Block	3
Prolonged PR	5
Transient A-V Dissociation	2
Atrial Flutter	1
Ventricular Tachycardia	1
TOTAL	59

Ectopic beats were the commonest. There were 23 episodes of atrial, 7 of nodal, and 8 of ventricular ectopics. Conduction defects (sinus bradycardia, abnormal P waves, intermittent sino-atrial block, prolonged PR interval, transient A-V dissociation) were detected on 19 occasions. In one patient with atrial fibrillation, who had previous mitral valvotomy and significant mitral regurgitation and whose C.T.R. was 0·66, marked sinus bradycardia (40-50 per minute) with abnormally low 'P' waves persisted for 6 weeks and was associated with vaso-vagal faints (Fig. 5). Following withdrawal of quinidine she reverted to atrial fibrillation.

In one patient with thyrotoxicosis, a 400 watt-seconds shock precipitated atrial flutter, after 100 and 200 watt-seconds had failed to convert the original atrial fibrillation. A further shock of 50 watt-seconds converted the atrial flutter to sinus rhythm.

Ventricular tachycardia was precipitated by a 100 watt-seconds shock in one patient with supra-ventricular tachycardia and a right bundle branch block, but this was successfully converted to sinus rhythm with a further shock of 200 watt-seconds.

T wave inversions were common particularly in the rheumatic group, but as most of these had recent mitral valvotomy, their significance is uncertain.

DISCUSSION

As with most things new, the initial enthusiasm for D.C. shock as a method for terminating arrhythmias was followed by a more cautious attitude, as more reports[11,12,13,14,15] of possible complications of this procedure were published. Thus one series[14] of 220 patients reported 14·5 percent complications directly related to the electrical treatment, including rise in serum enzyme levels, cardiac enlargement, pulmonary venous congestion and oedema, electrocardiographic changes, pulmonary or systemic embolic and ventricular fibrillation. Some are of minor significance, while others are rare, or may occur whatever the method of achieving sinus rhythm. Most are related to the use of high energy shocks and improper technique. Nevertheless, as pointed out by Lown[4], electroconversion aviods some of the serious disadvantages of anti-arrhythmic drugs. Thus, with drug therapy, the margin between therapeutic and toxic dose may be difficult to predict and often uncomfortably small in the individual patient, so that tedious biological titration and close monitoring are necessary, and even then serious toxic effects may occur. Most anti-arrhythmic drugs not only suppress ectopic foci, but also depress myocardial function and the excitability of the normal pacemakers, and reduce peripheral resistance in patients whose cardiac reserve may already be low because of the underlying disease or the arrhythmia itself.

In this series, other than for one case of ventricular tachycardia following D.C. shock, which was easily converted with a second shock, no serious complications were encountered.

Under favourable circumstances, D.C. shock appears to be the safest and most effective method for terminating cardiac arrhythmias. It must, however, be regarded as a major procedure, to be carri-

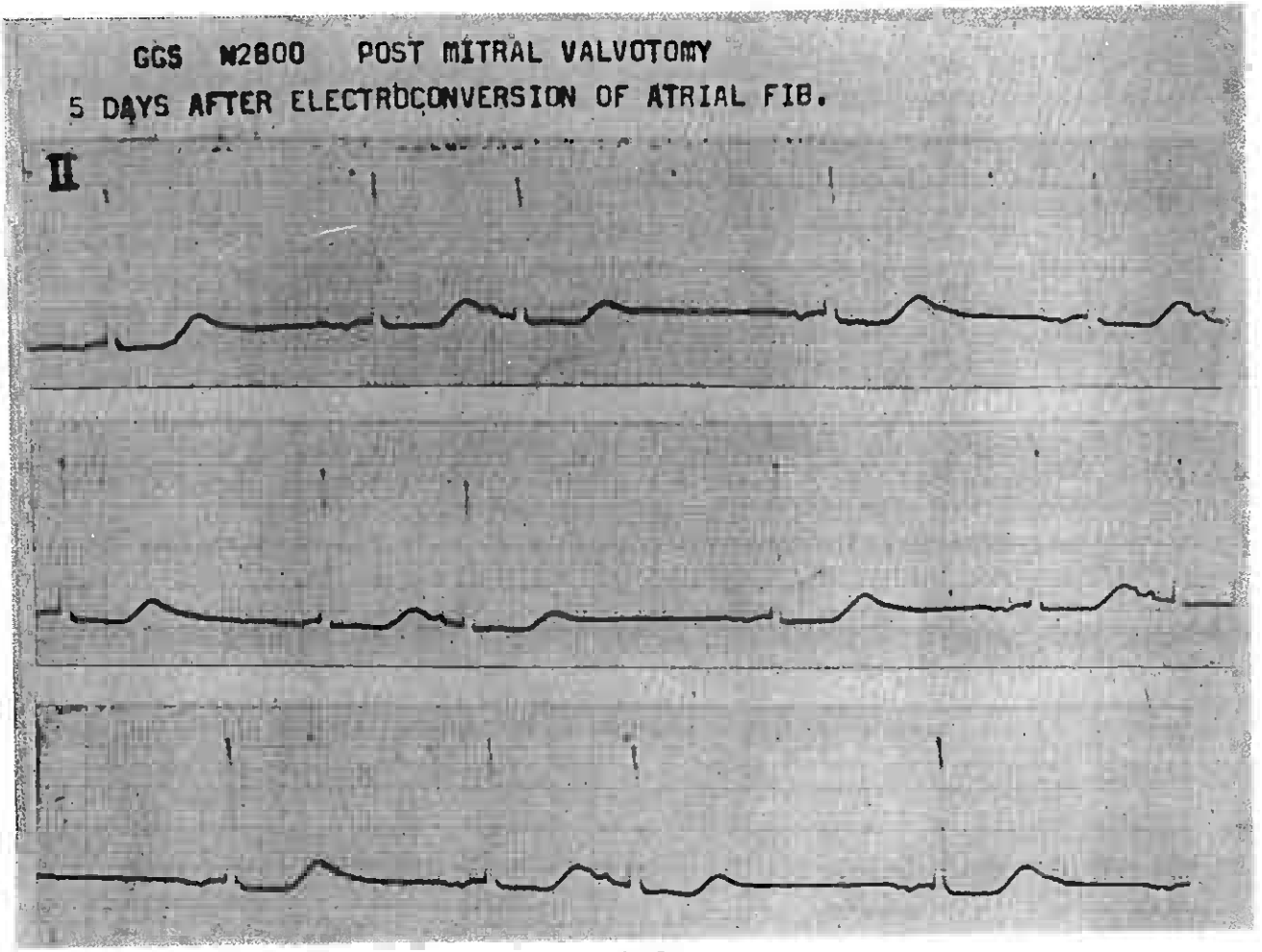

Fig. 5.

ed out only where facilities for monitoring and dealing with complications are available, and by personnel who are conversant with both the technique and the equipment.

Our overall immediate successful conversion rate of 88·5% compares favourably with results of other reported series[6,7,9,10,16,17,18]. Atrial fibrillation with an immediate successful conversion rate of 77·4% and persistence of sinus rhythm in only 6 out of 22 converted episodes followed for over a year, gave the most disappionting result. As 20 out of the 25 patients with this arrhythmia had rheumatic mitral stenosis, it is uncertain whether atrial fibrillation associated with other cardiac conditions would give similar results. Radford and Evans[17] reported more encouraging long term results in those with thyrotoxicosis and "lone" atrial fibrillation. Patients with a long history of atrial fibrillation generally do worse than those with atrial fibrillation of recent onset, as is borne out by our follow up results.

Other factors which have been shown to influence chance of successful conversion and persistence in sinus rhythm, but not demonstrable with this small series, are radiographic size of left atrium, cardio-thoracic ratio and amplitude of 'f' waves in the E.C.G.[4,10]. Atrial fibrillation associated with congenital heart disease or occurring post-operatively, also appears to respond better[19].

Atrial flutter and ventricular tachycardia gave the best results, as all but one episode of each arrhythmia were converted with only one shock. We now hold the view that if digitalisation fails to convert atrial flutter, D.C. shock should be resorted to, in preference to anti-arrhythmic agents, as failure with electroconversion is most unusual. Anti-arrhythmic agents like lignocaine, phenytoin, antazoline, on the other hand, may precipitate dangerous tachycardia by facilitating atrio-ventricular conduction in atrial flutter.

Supraventricular and ventricular tachycardia were easy to convert but more difficult to maintain in sinus rhythm. However, where conversion of supraventricular tachycardia with usually adequate dosages of an anti-arrhythmic drug has failed, as in all our patients, electroconversion is justified and is preferable to treatment with additional drugs. Ventricular tachycardia always demands more urgent attention, as cardiac failure and hypotension are more frequent, and in the view of Lown[4], electroconversion is the treatment of choice. A short trial of drug therapy may be justified but the decision to cardiovert should not be long postponed.

Analysis of the energy settings for successful conversion indicates that most patients with atrial fibrillation, and almost all patients with the other arrhythmias will respond to 100 watt-seconds or less. There is some evidence that very low energy shocks are more likely to induce serious arrhythmias, while high energy settings more than 300 watt-seconds may be associated with a higher rate of post-conversion complications[14]. For these reasons, we prefer to start with energy settings in the medium range for the initial shock viz. 50 watt-seconds in atrial flutter, and 100 watt-seconds for the other arrhythmias.

ACKNOWLEDGEMENTS

We wish to thank our medical colleagues who referred patients for treatment, and the nursing staff of the Renal-Coronary Care Units, Medical Unit II, Outram Road General Hospital, for their enthusiastic assistance.

We are also indebted to the benefactors of the Coronary Care Unit for their generous donations toward the purchase of the equipment.

REFERENCES

1. Kouwenhoven, W.B., Hooker, D.R. and Langworthy, O.R.: "The current flowing through the heart under conditions of electric shock." Amer. J. Physiol., 100, 344, 1932.
2. Beck, C.S., Pritchard, W.H. and Feil, H.S.: "Ventricular fibrillation of long duration abolished by electric shock." J. Amer. Med. Ass., 135, 985, 1947.
3. Alexander, S., Kleiger, R. and Lown, B.: "Use of external electric countershock in the treatment of ventricular tachycardia." J. Amer. Med. Ass., 177, 916, 1961.
4. Lown, B.: "Electrical Reversion of Cardiac Arrhythmias." Brit. Heart J., 29, 469, 1967.
5. Lown, B., Amarasingham, R. and Newman, J.: "New method for terminating cardiac arrhythmias. Use of synchronised capacitor discharge." J. Amer. Med. Ass., 182, 548, 1962.
6. Lown, B.: "Cardioversion of arrhythmias (I)." Mod. Conc. Cardiovasc. Dis., 33, 863, 1964.
7. Lown, B.: "Cardioversion of arrhythmias (II)." Mod. Conc. Cardiovasc. Dis., 33, 869, 1964.
8. O'Brien, K., Resnekov, L. and McDonald, L.: "Direct-current countershock in the treatment of drug-resistant arrhythmias." In proceedings of the British Cardiac Society. Brit. Heart J., 26, 137, 1964.
9. Oram, S. and Davies, J.P.H.: "Further experience of electrical conversion of atrial fibrillation to sinus rhythm: analysis of 100 patients." Lancet, 1, 1294, 1964.
10. Resnekov, L. and McDonald, L.: "Appraisal of eclectroconversion in treatment of cardiac dysarrhythmias." Brit. Heart J., 30, 786, 1968.
11. McDonald, E.L. and Resnekov, L.: "Atrial fibrillation in Resuscitation and Cardiac Pacing." Ed. G. Shaw, G. Smith, and T.J. Thomson, p. 140. Cassell, London, 1964.
12. Rabbino, M.D., Likoff, W. and Dreifus, L.W.: "Complications and limitations of direct-current countershock." J. Amer. Med. Ass., 190, 417, 1964.
13. Resnekov, L. and McDonald, L.: "Pulmonary oedema following treatment of arrhythmias by direct-current shock." Lancet, 1, 506, 1965.
14. Resnekov, L. and McDonald, L.: "Complications in 220 patients with cardiac dysarrhythmias treated by phased direct current shock, and indications for electroconversion." Brit. Heart J., 29, 926, 1967.
15. Hurst, J.W., Paulk, E.A. Jr., Proctor, H.D. and Schlant, R.C.: "Management of patients with atrial fibrillation." Amer. J. Med., 37, 728, 1964.
16. Pantridge, J.F. and Halmos, P.S.: "Conversion of atrial fibrillation by direct current counter shock." Brit. Heart J., 27, 128, 1965.
17. Radford, M.D. and Evans, D.W.: "Long-term results of D.C. reversion of atrial fibrillation." Brit. Heart J., 30, 91, 1968.
18. Selzer, A., Kelly, J.J. Jr., Johnson, R.B. and Kerth, W.J: "Immediate and long-term results of electrical conversion of arrhythmias." Progr. Cardiovasc. Dis., 9, 90, 1966.
19. Nachlas, M.M., Brix, H.H., Mower, M.M. *et al*: "Observations on defibrillators, defibrillation and synchronised Counter-shock." Progr. Cardiovasc., 9, 46, 1966.