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Electrocardiographic Changes during the First Few Seconds after Cardioversion of Atrial Fibrillation and Flutter

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ABSTRACT

Electrocardiograms were registered with a special technique during attempts at cardioversion in 22 patients with atrial fibrillation or flutter. The registrations permitted analysis of the electrocardiogram 0.1–0.5 s after the electrical discharge. Mean values indicate that there is no compensatory pause after the d.c. shock. After 29 of the 42 synchronized d.c. shocks the first QRS complex was aberrant.

INTRODUCTION

Several authors have studied electrocardiographic changes after cardioversion of atrial fibrillation and flutter. The literature in this field has been reviewed by Friedemann (2) and by Castellanos & Lemberg (1). The methods used have not permitted analysis of the electrocardiogram during the first 1.2–2.0 post-shock seconds.

In order to study what happens immediately after cardioversion, other methods have been used. Lown (3) reports that 'when systemic pressure is recorded during cardioversion, the change in pressure contour simulates that of ventricular extrasystole and results in a compensatory pause which equals about two cycles'. Friedemann (2) used cinefluorography and could not find any compensatory pause of the ventricles. The method did not permit studies of the atria. The aim of the present investigation was to study the electrocardiogram during the first few seconds after cardioversion, using a special recording technique.

MATERIAL AND METHODS

The registrations were made during attempts at cardioversion in 20 patients (7 women, 13 men) with atrial fibrillation and 2 patients (men) with atrial flutter. The particular patient group was selected, others being eliminated because prolonged arrhythmia, marked enlargement of the heart, and advanced age were judged as relative contraindications for attempts at cardioversion. Digitalis treatment was interrupted at least 2 days before the cardioversion and in most cases even quinidine treatment was interrupted. All the patients had normal values for K^+ in serum on the day the attempt at cardioversion was made. As pre-medication, the patients received injections of 25 mg promethazin and 25 mg pethidin half an hour prior to the attempt at cardioversion. The d.c. shock was given with the patient anaesthetized with intravenously administered diazepam. The d.c. shock was given with a defibrillator (Sirecard S, Siemens Ltd.), which has a discharge with a pulse-width of approximately 10 ms. over 50 ohms for 100% discharge. Synchronization of the d.c. shock with QRS was successfully obtained in all but one case. Anterolateral placement of the paddles was used. In general we started with an energy setting of 100 Ws. Lower energy settings were used for the patients with atrial flutter.

The electrocardiogram was registered with a special technique developed by Nordgren (5). Three bipolar chest leads were recorded. A common electrode was placed at the angle of sternum and three different electrodes were placed at the highest point in the left mid-axillary line (S 1), over the caudal end of the sternal body (S 2), and at a point over the vertebral column at the level of the sternal angle (S 3).

The three bipolar chest leads were recorded with both conventional amplification (1 mV = 10 mm) and with tenfold amplification using a 3-channel differential preamplifier. The electrocardiogram was recorded with a Mingograph 81 (Siemens-Elema Ltd., Sweden). In order to protect the preamplifier from overvoltage at discharge, the preamplifier was provided with serial resistances of 5.6 kohms in the input leads and antiparallel protective diodes between the preamplifier inputs and ground. In order to recover the electrocardiogram-signal as soon as possible after the d.c. shock, the RC-time was reduced to 0.03 s by reducing the capacitors of the preamplifier.

Measurements of the f-wave frequency were performed on 20 consecutive f-waves.

Table I. *Reversion to sinus rhythm, synchronized d.c. shock (n=22)*

	Energy level (Ws)	"Missed time QRS" (s)	R–R interval, s final	R–R interval, s first	"Missed time P" (s)	Time interval until first P, (s)	First PQ time (s)
Mean	189	0.26	0.71	0.66	0.89	1.54	0.22
Range	60–400	0.1–0.5	0.4–1.6	0.4–1.5	0.3–1.8	0.8–3.4	0.14–0.40

RESULTS

The 22 patients received together 43 d.c. shocks. Of these, 23 gave sinus rhythm in 21 of the patients. In one patient reversion could not be achieved and 2 patients returned to atrial fibrillation within a few minutes and were therefore given another d.c. shock which once again gave reversion to sinus rhythm.

The d.c. shock which was not synchronized gave reversion to a sinus rhythm, but after an asystole lasting 3.8 s.

The results of the electrocardiographic studies in connection with successful, synchronized d.c. shocks are shown in Table I. "Missed time QRS" means the time immediately after the electrical discharge when a QRS complex, if it occurred, was concealed by the shock artefact.

The first ventricular complex after the d.c. shock came after an average of 0.66 s, while the final R–R interval before the d.c. shock was, on the average, 0.77 s. Thus, judging from mean values, no compensatory pause was found. In 2 of the 22 cases the first R–R interval after the d.c. shock was at least twice as long as the final pre-shock R–R interval. The first ventricular complexes in these 2 cases came after 1.0 and 1.5 s respectively, and were preceded by P waves.

In 17 of the 22 synchronized shocks which gave reversion to sinus rhythm, the first identified QRS complex after the d.c. shock was aberrant compared with pre-shock QRS and was not preceded by a P wave. In 6 of the cases, at least the first 2 QRS complexes were aberrant, while 3 or more consecutive aberrant complexes were seen in 3 cases.

"Missed time P" means the time after the d.c. shock during which a P wave, if it occurred, could not be identified due to shock artefact, muscle disturbances or occurrence of aberrant ventricular complexes. Thus the values given for the time interval until the first P wave are not very reliable, especially in those cases with 2 or more aberrant ventricular complexes immediately after the d.c. shock. The method used does not permit identification of P waves which occur simultaneously with QRS complexes. The values given for the time interval until the first P wave should be regarded as maximum values.

The first PQ time may also be incorrect in some cases, if the first P wave has been missed.

Twenty of the d.c. shocks failed to give reversion to sinus rhythm. The results of the electrocardiographic studies in these cases appear in Table II. In this group too, no compensatory pause after the d.c. shock was found. The first recorded QRS complex after the electrical discharge was aberrant after 12 of the d.c. shocks, in 4 cases at least the first 2 QRS complexes were aberrant, while 3 or more consecutive aberrant complexes were found in 3 cases. Figure 1 shows 3 consecutive aberrant QRS complexes after a d.c. shock with an energy setting of 100 Ws.

The occurrence of aberrant ventricular complexes immediately after cardioversion was more

Table II. *No reversion to sinus rhythm (n=20)*

	Energy level (Ws)	"Missed time QRS" (s)	R–R interval, s final	R–R interval, s first	f-waves/min before	f-waves/min after
Mean	117	0.26	0.73	0.54	425	426
Range	10–200	0.2–0.4	0.4–0.6	0.3–1.4	280–540	320–540

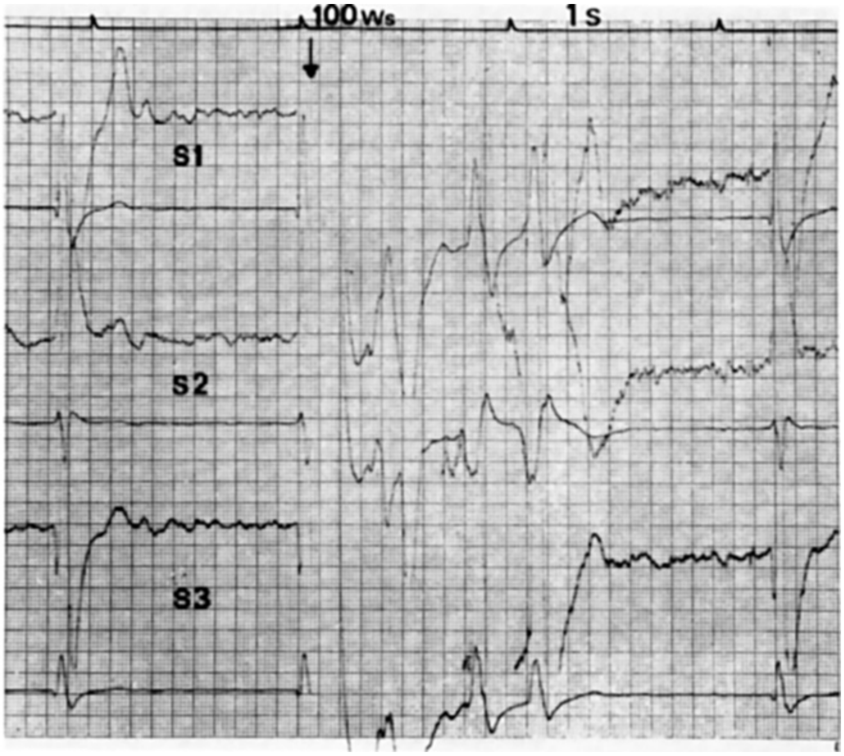

Fig. 1. Registration of three bipolar chest leads during attempt at cardioversion in a patient with atrial fibrillation. The electrical discharge is followed by 3 aberrant QRS complexes. Reversion to sinus rhythm is not obtained.

common at higher energy levels. Without exception, patients with aberrant ventricular complexes after a low-energy d.c. shock exhibited aberrant complexes even after d.c. shock with higher energy setting.

The f-wave frequency and configuration did not show any evident changes when studied the final 30 s before and the first 30 s after the electrical discharge.

DISCUSSION

It is well known that an electrical discharge occurring during the vulnerable period of the ventricles can produce ventricular fibrillation. Lown, Amarasingham & Neuman (4) introduced synchronization of the d.c. shock with the spontaneous ventricular complex in order to decrease the risk of ventricular fibrillation. With this technique the occurrence of ventricular arrhythmia after the d.c. shock has not been common (3).

The results of this study point out that even with synchronization of the d.c. shock, the occurrence of aberrant ventricular complexes after the d.c. shock is not uncommon. In general, this disturbance is brief and cannot be registered if recording is started 2 s after the electrical discharge.

The results of this study indicate that a compensatory pause after the d.c. shock is not a common occurrence, whether after successful or unsuccessful d.c. shock. The finding of signs of compensatory pause when systemic pressure is recorded during cardioversion can perhaps be due to the electrical activity in the ventricles causing low mechanical activity during the first seconds after the electrical discharge.

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