and haematology, the General Infirmary at Leeds, for processing the fluid samples.

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Transthoracic ventricular defibrillation in adults

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Summary

A prospective study of the energy required for transthoracic ventricular defibrillation in adults showed that in 42 (81%) out of 52 episodes of ventricular fibrillation shocks of 100 watt-seconds (W s) of stored energy were successful. Out of 233 episodes, 222 (95%) were converted by 200 W s shocks. Among patients in whom primary ventricular fibrillation occurred within one hour of the onset of acute myocardial infarction, 200 W s shocks were successful in 40 (98%) out of 41 episodes. When low-energy shocks failed, a stored energy of 400 W s invariably succeeded.

The need for large and expensive defibrillators that store more than 400 W s and are less readily available is therefore questioned.

Introduction

To effect transthoracic ventricular defibrillation in adults most workers advocate shocks of the maximum energy that can be stored by the defibrillator, which is usually 400 watt-seconds (W s).[1 2] It is not clear why shocks of 400 W s stored energy are recommended.[3] Tacker *et al*[4] stated that in 35% or more of patients weighing over 50 kg and in 60% of patients weighing between 90 and 100 kg the maximum energy that could be delivered from commercially available defibrillators failed to correct ventricular fibrillation. They therefore suggested that defibrillators should store more than 400 W s. Pantridge *et al*[5] reported preliminary observations on the use of 200 W s stored energy. We report the results of a further, prospective investigation into the correction of ventricular fibrillation with low-energy shocks.

Patients and methods

The study was made up of two parts and was carried out on 214 patients. The patients in Part I received an initial shock of 200 W s stored energy—that is, 150-165 W s delivered (see table I). Patients in Part II received an initial shock of 100 W s stored energy—that is, 74-82 W s delivered.

PART I

Part I included 233 episodes of ventricular fibrillation observed in 120 patients between August 1974 and December 1975. Ninety-one patients were men aged 38 to 81 years (mean age 60 years) and 29 were women aged 26 to 78 years (mean age 61). Of the 120 patients, 63 had a single episode of ventricular fibrillation; 98 (82%) had had an acute myocardial infarction; and 45 had had one or more previous myocardial infarcts. Seven patients had acute coronary insufficiency, and nine had cardiac failure complicating chronic ischaemic or rheumatic heart disease. Other causes of ventricular fibrillation were present in six patients.

The duration of ventricular fibrillation before attempted conversion varied from four seconds to 34 minutes. It was two minutes or less in 177 (76%) of the 233 episodes. The time from onset of symptoms to the onset of ventricular fibrillation in patients with acute infarction ranged from 0 minute to 31 days. One hundred and eleven episodes occurred within six hours of the onset of symptoms of infarction, and 46 episodes occurred within one hour. Of the 120 patients, 81 had 150 episodes of primary ventricular fibrillation—that is, fibrillation occurring in the absence of cardiac failure or shock (systolic blood pressure less than 80 mm Hg)—and 39 had 83 episodes of secondary fibrillation. The episodes occurred both outside and inside hospital.

Two types of defibrillator were used, each charged to 200 W s (table I). The Pantridge portable defibrillator was used in 177 of the 233 episodes and the American optical in the remainder. The paddles (8·5 cm diameter) were covered with a low resistivity saline electrode jelly. One was positioned immediately below the clavicle, to the right of the sternum, and the other on the anterior axillary line at the level of the fifth left intercostal space.

When the initial shock failed to remove ventricular fibrillation a further shock of identical energy was applied immediately. The effect of each shock was observed on a continuous electrocardiogram. Defibrillation was regarded as successful when ventricular fibrillation was converted to another rhythm—for example, sinus rhythm, atrial fibrillation, or asystole.

PART II

The effects of shocks of 100 W s stored energy were documented in 161 episodes of ventricular fibrillation that occurred in 94 patients seen between January 1976 and March 1977. Sixty of the 94 patients had a single episode. Sixty-eight were men aged 18 to 82 years (mean age 60 years) and 26 were women aged 21 to 80 years (mean age 65). Sixty-one of the 94 patients (65%) had had an acute myocardial infarction, and 45 had had one or more previous myocardial infarcts. Fourteen patients had acute coronary insufficiency, and four had cardiac failure complicating chronic ischaemic heart disease. There were other causes of the dysrhythmia in 15 patients.

The duration of ventricular fibrillation before attempted conversion

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TABLE I—*Amounts of stored and delivered energy and charge times for defibrillators*

Stored energy (W s)	Delivered energy (into 50Ω) (W s)		Charge time (s)	
	Pantridge portable	American optical	Pantridge portable	American optical
400	330	270	8·5	13·0
200	165	150	5·0	7·0
100	82	74	3·0	5·5

varied from 11 seconds to 30 minutes, and in 113 episodes it was two minutes or less. In patients with acute myocardial infarction the time from onset of symptoms to the onset of ventricular fibrillation ranged from 0 minute to 29 days, 41 episodes occurring within six hours and 15 episodes within one hour. Sixty-eight patients had 99 episodes of primary ventricular fibrillation, and 36 patients had 62 episodes of secondary ventricular fibrillation. Ten patients had both primary and secondary ventricular fibrillation.

The Pantridge portable defibrillator was used in 159 of the 161 episodes. When shocks of 100 W s were required the Pantridge defibrillator could be charged and discharged three times in 13 seconds.

All patients received an initial shock of 100 W s (stored energy). In the first 24 patients, if defibrillation was unsuccessful a second 100 W s shock was applied immediately, and if this failed a third, identical shock was given. If all three shocks were unsuccessful a shock of 400 W s was applied. In the remaining 70 patients, if a shock of 100 W s was unsuccessful a 200 W s (stored energy) shock was applied immediately, and if this was unsuccessful a 400 W s shock was given.

Results

PART I

Of the 233 episodes, 222 (95%) were successfully converted with 200 W s stored energy (table II). A single shock was successful in 199 episodes. In 20 episodes the second 200 W s shock was successful, and in three, three 200 W s shocks were required. Stored energy of 200 W s was successful in 143 (95%) of the 150 episodes of primary ventricular fibrillation (including 40 (98%) of the 41 episodes that occurred within one hour of the onset of acute myocardial infarction).

The relation between body weight and success of 200 W s (stored) shocks is shown in table III. Three episodes of ventricular fibrillation occurred in two patients, who each weighed 102 kg. In two of the three episodes a 200 W s shock was successful. In patients weighing more than 60 kg, 190 (95%) of the 199 episodes were successfully converted; in those weighing more than 80 kg, ventricular fibrillation was removed in 43 (90%) of the 48 episodes—that is, in 30 (91%) of the 33 episodes of primary ventricular fibrillation and in 13 (87%) of the 15 episodes of secondary ventricular fibrillation.

TABLE II—*Success of defibrillation with shocks of either 165 or 150 W s (delivered energy)*

Type of ventricular fibrillation	No of episodes	Successful conversions	
		No	%
Primary	150	143	95
Within 1h of onset of MI	41	40	98
Secondary	83	79	95
Total	233	222*	95

*199 (85%) with one shock, 20 (9%) with two shocks, and 3 (1%) with three shocks.
MI = Myocardial infarction.

TABLE III—*Success of defibrillation with 200 W s (stored energy) related to body weight in patients weighing 30-100 kg*

Body weight (kg):	30-40	-50	-60	-70	-80	-90	-100
No of episodes	1	2	31	97	54	29	16
% successful conversions	100	100	94	97	98	90	94

Shocks of 200 W s were unsuccessful in correcting ventricular fibrillation in 11 of the 120 patients. The weights of these patients varied between 51 and 102 kg. Seven had primary ventricular fibrillation and four secondary ventricular fibrillation. Successful conversion with 400 W s occurred in 10 of these patients. In the last patient, who was 81 years old and had secondary ventricular fibrillation complicating ischaemic heart disease and a neoplasm of the oesophagus, a 200 W s shock successfully converted the first episode of ventricular fibrillation but not the second; higher energies were not used. Despite the successful conversion with 400 W s in 10 of the 11 patients, only five survived to leave hospital.

Sixty of the 120 patients died, some while still in hospital. Of the 81 patients with primary ventricular fibrillation, 55 (68%) were long-term survivors. Of the 19 patients who experienced 41 episodes of primary ventricular fibrillation within one hour of the onset of symptoms of acute infarction, 12 (63%) were discharged from hospital.

PART II

A shock of 100 W s (stored energy) was successful in 53 (56%) of the 94 patients and in 101 (63%) of the 161 episodes. Defibrillation was more often successful when the initial shock was given soon after the onset of ventricular fibrillation. When ventricular fibrillation had been present for two minutes or less the initial 100 W s discharge was successful in 77 (68%) of 113 episodes, whereas when the duration of ventricular fibrillation exceeded two minutes only 24 out of 48 episodes were converted ($P < 0·05$).

The first 24 patients, who had 55 episodes of ventricular fibrillation, should have received up to three 100 W s shocks. In three episodes, however, other energies were given. Thus the effects of up to three consecutive 100 W s shocks were observed in 52 episodes among 23 patients. In 14 (61%) of the 23 patients the initial episode of ventricular fibrillation was converted to another rhythm. Forty-two of the 52 episodes (81%) were successfully converted with 100 W s shocks (table IV): in 35 episodes (67%) a single shock was successful; in six the second shock was successful; and in one, three shocks were necessary. The 10 episodes that failed to convert with 100 W s shocks were successfully converted with 400 W s, although one patient required two shocks of 400 W s and another needed four.

TABLE IV—*Success in 52 episodes of ventricular fibrillation of shocks of 100 W s (stored energy)*

No of 100 W s shocks	1	2	3
No (%) of successful conversions	35 (67)	6 (12)	1 (2)

Seventy patients with 106 episodes of ventricular fibrillation were to receive a sequence of 100, 200, and 400 W s shocks if required. In four episodes, however, the shocks were given incorrectly, and so 68 patients with 102 episodes received the planned sequence. In 59 (87%) of the 68 the first episode of ventricular fibrillation in each patient was successfully converted by one or more shocks in the sequence. The sequence was successful in 93 (91%) of the 102 episodes: a single shock of 100 W s (stored) was successful in 66 episodes; in 20 episodes the second shock (200 W s) was successful; and in seven the third shock (400 W s) was successful. The nine episodes of ventricular fibrillation that could not be corrected by the sequence were corrected by further 400 W s shocks.

Fifty-one of the 94 patients (54%) died, some during their hospital stay. Of 58 patients with primary ventricular fibrillation, 38 (66%) were long-term survivors. Of the 12 patients in whom 15 episodes of primary ventricular fibrillation occurred within the first hour of the onset of symptoms of infarction, 8 (67%) survived to leave hospital.

Discussion

The differences between our results and those of Tacker *et al*[1] require comment. The study of Tacker *et al* was retrospective and was carried out on hospital patients, 40% of whom developed ventricular fibrillation after cardiac surgery.[6] Tacker *et al*[1] did not note either the proportion of patients with ischaemic heart disease or how many patients had secondary ventricular fibrillation—that is, ventricular fibrillation complicating cardiogenic shock or pump failure. Our study was prospective.

Of the 214 patients, 192 (90%) had ischaemic heart disease, and 159 (74%) had had an acute myocardial infarction. Primary ventricular fibrillation occurred in 139 (65%).

Many factors affect the success of defibrillation, and one of the most important is the duration of ventricular fibrillation before attempted conversion. Increased oxygen consumption is associated with the asynchronous and very rapid rate of contraction of the fibres of the fibrillating heart.[7 8] Even a brief interruption of coronary flow might be expected to increase myocardial injury and thus increase the difficulty in removing ventricular fibrillation.

Although external cardiac massage and ventilation will maintain the viability of the cerebrum for 20 minutes or longer,[9] it is important to recognise the limitations of cardiopulmonary resuscitation. The report of Kouwenhoven *et al*[9] showed that the arterial pressure obtained during chest compression is about 80 mm Hg, while between compressions it is some 20 mm Hg. Thus the mean coronary perfusion pressure is usually less than 70 mm Hg. A mean pressure below 70 mm is unlikely to be associated with perfusion of ischaemic areas of the myocardium. Progression of myocardial injury may explain the inverse relation between the duration of cardiopulmonary resuscitation and the chance of survival. In this study ventricular fibrillation was present for two minutes or less in 74% of the episodes. Tacker *et al*[1] did not indicate the duration of ventricular fibrillation in their study.

Tacker *et al*[1] did not record details of the defibrillation technique or indicate the training and experience of the personnel concerned. It has become clear that paddle positions[10 11] and their application,[12] electrode paste, and paddle size[13] influence the amount of stored energy required for the successful removal of ventricular fibrillation. In our prospective study the personnel were medically qualified, and all had experience of coronary care and had received intensive training in resuscitation techniques. The paddles used were 8·5 cm in diameter. One was placed to the right of the sternum, below the clavicle, and the other in the fifth left intercostal space in the anterior axillary line. The electrode paste was chosen to give maximum reduction in transthoracic impedance.

The concept of weight-related energy dose proposed by Tacker and Geddes[14] advocated the use of 4-6 J/kg body weight. They also said that for patients over 100 kg the initial shock should exceed 500 W s (delivered energy)[15] and that if the initial shock fails the energy should be increased by increments of 100-200 W s.[16] Our experience indicates that a second shock of identical energy often succeeds when the initial shock has failed. This was also the experience of Mackay and Leeds.[17] That heavy patients require high-energy shocks does not accord with the experience of others. Curry and Quintana[18] reported the success of a single shock of 300 W s in a case of ventricular fibrillation that occurred after acute myocardial infarction in a woman weighing 108 kg. Lappin[19] corrected ventricular fibrillation in a man weighing 145 kg with one 400 W s shock (stored energy). In this study there were three episodes of ventricular fibrillation in two patients who weighed 102 kg. A single shock of 200 W s (stored) was successful in two of these episodes; in the other, shocks of 400 W s (stored) succeeded.

Our findings do not support the proposition of Ewy and Tacker[20] that defibrillators capable of delivering 500-1000 W s should be developed. Indeed, it seems more logical to develop small, cheap, and more readily available machines, whose stored energy need not exceed 400 W s.

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Cervical ripening with intravaginal prostaglandin E_2 gel

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Summary

We describe a technique of administering prostaglandin E_2 (PGE_2) in a viscous cellulose gel into the vagina to ripen the unfavourable cervix in patients requiring induction of labour. A total of 168 primigravidae were studied, of whom 102 received 2 mg PGE_2 in 2% gel and 66 received 5 mg PGE_2 in 4% gel. In the latter group, the state of the cervix was significantly improved in 58 patients (87·9%), while 32 (48·5%) had started labour before planned induction. There were no maternal or fetal side effects or complications.

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Introduction

The state of the uterine cervix has an important influence on the outcome of induced labour—particularly affecting the duration of labour, the incidence of maternal and fetal complications, and the need for caesarean section. For routine use in