They had a higher success rate in the accident and emergency department where the defibrillator was kept.

Two main reasons may account for our relatively high success rate. The availability of resuscitation ambulances encourages earlier admission after infarction[3] and therefore leads to more primary fibrillation in hospital. Of the 68 survivors of circulatory arrest who were admitted in these ambulances, 22 were resuscitated within 30 minutes of arriving at the hospital. In more conventional circumstances most of these 22 patients might have developed ventricular fibrillation before admission. The second reason is immediate access to resuscitation equipment throughout the hospital and the ability of nurses on the open general wards to defibrillate promptly on their own initiative. We believe that the chances of ultimate success are inversely related to the duration of the circulatory arrest, which must be shorter when observation is close and suitably trained personnel are at hand.

The role of coronary care units is being debated and it is becoming clear that some patients with an acute myocardial infarction can be managed at home,[12 13] particularly when complications are absent and diagnosis is made three or more hours after the onset of symptoms. We emphasise that our high success rate for defibrillation in general medical wards does not imply that a specialised unit is unnecessary. We believe that one of the principal functions of a coronary care unit is to train doctors and nurses from all areas of the hospital in resuscitation procedures. The influence of a successful unit should extend throughout the general wards and into other departments. We believe that our results underline the value of this philosophy. There is no real paradox in the statement that only a hospital with an efficient coronary care unit does not then need one.

Defibrillators and monitoring equipment have been donated by the Brighton Rotary Club, Brighton Lions, Hove Lions, and Hove Round Table. Contributions have also been made by many private individuals. Our resuscitation system could not have functioned so effectively without this help. Many nurses have studied long hours in their own time in order to play a leading part in resuscitation procedures.

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Current required for ventricular defibrillation

J N PATTON, J F PANTRIDGE

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Summary and conclusions

The mean current required for ventricular defibrillation was measured and found to be 0·35 ± SE 0·03 A/kg body weight, which is about one-third of that predicted from animal experiments. There was no apparent correlation between the current required and body weight (r = −0·007 ± SE 0·213).

There is no evidence of need for defibrillators storing more than 400 J.

Introduction

A major problem regarding ventricular defibrillation is to determine the energy required for consistently effective treatment. Geddes *et al*[1] postulated that current, particularly current/kg body weight, is a better measure of requirements. We have therefore measured the peak current required for ventricular defibrillation and report here our results.

Royal Victoria Hospital, Belfast BT12 8BA

J N PATTON, BSC, MRCP, senior registrar in cardiology
J F PANTRIDGE, MD, FRCP, professor of cardiology

Methods

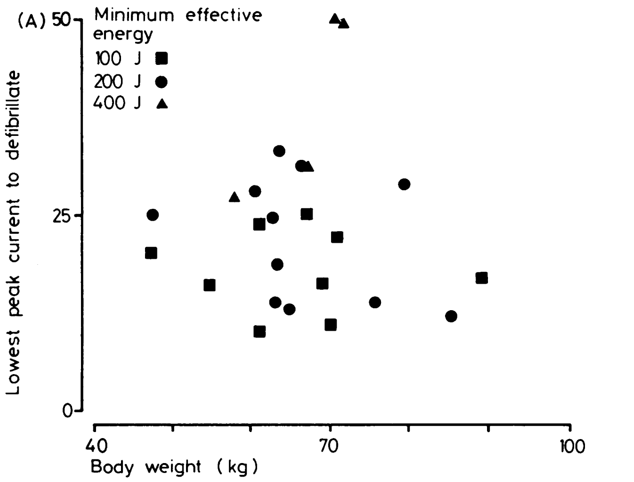
Two DC defibrillators were modified by placing a 1 Ω resistor in series with the paddles. The peak current discharged through the resistor (and hence through the chest) was measured by an electronic circuit incorporated in the defibrillator. Results were displayed digitally. The defibrillators were sited in the coronary care unit and on the resuscitation trolley. Patients with ventricular fibrillation were given a shock of 100 J; if this failed 200 J was given (see table). In the few patients in whom low energy was unsuccessful ventricular fibrillation was terminated with 400 J. On each occasion the peak current was noted. The patients were weighed as soon as possible after resuscitation.

Results

Out of 24 patients resuscitated, 20 had acute myocardial infarction. The table gives the age and weight of the patients and the current required. The figure shows the minimum peak currents required plotted against body weight and the stored energy required in each

Details in 24 cases of patients resuscitated with shocks of 100, 200, and 400 J of stored energy. Mean values expressed ± SE

	Stored energy (J)		
	100	200	400
No of patients treated	9	11	4
No with primary ventricular fibrillation	6	7	4
No with myocardial infarction	9	8	3
Mean weight (kg)	65·5 ± 3·9	66·8 ± 3·1	67·2 ± 3·1
Mean age (years)	63·1 ± 4·3	59·2 ± 3·2	60·8 ± 5·6
Mean current (A)	17·9 ± 1·8	22·1 ± 2·4	39·3 ± 6·0



Minimum peak currents required for ventricular defibrillation in patients of different body weights, and stored energy needed in each case.

case. The same value of stored energy delivered differing amounts of current to different subjects and to the same subjects at different times, indicating a variation in transthoracic resistance.

The mean current required for defibrillation in our patients was 0·35±SE 0·03 A/kg body weight, which contrasts with the 1·0 A/kg suggested by Geddes *et al*.[1] There was no obvious relation between body weight and the current required for defibrillation (see figure; r = −0·007±SE 0·213).

Discussion

In 1899 Prevost and Batelli[2] discovered that a capacitor discharge abolished ventricular fibrillation. This was confirmed by Gurvich and Yuniev,[3] who also showed that damping and prolonging the discharge by adding a small inductance to the circuit (0·5 H or less) increased its effectiveness. In 1953 Mackay and Leeds[4] quantified the inductance and found that a value of 1 H halved the energy required for defibrillation. Nine years elapsed, however, before Lown *et al*[5] and Edmark[6] introduced the damped capacitor discharge into clinical use to replace AC defibrillators. The defibrillators used by Lown *et al* and Edmark stored no more than 400 J.

The energy required for defibrillation is being intensively investigated by the United States Food and Drugs Administration and other responsible bodies. The FDA is considering whether enough data are available to determine standards adequate to control the safety and effectiveness of defibrillators.[7] If this is not possible the devices will be placed in class III, which means that scientific data establishing their safety and effectiveness are still required. This has obvious implications regarding the possible widespread availability of defibrillators.

Because of claims by the Purdue workers that shocks of over 400 J may be needed to defibrillate more than one-third of adult patients[8] a concept of weight-related dosage has been formulated and nearly half of the manufacturers now produce instruments that store over 400 J.[9] Prototypes delivering 1000 J have been developed.[10] Defibrillators storing over 400 J are less portable than conventional devices and hence less readily available for patients at risk. Serious doubts have been raised about the need for shocks of high energy.[9, 11–14] No evidence has been produced that they are effective in the few cases where low energy fails. Campbell *et al*[12] reported that 95% of patients could be defibrillated with shocks of 165 J delivered energy. They failed to find a relation between body weight and the success of defibrillation. More recently, Tacker *et al*[15] showed a lack of correlation between the energy required for defibrillation and heart weight.

Since the energy dose-body weight related concept and the introduction of kilowatt defibrillators appeared likely to increase the risk of shock-induced myocardial damage, the validity of the concept was investigated. All workers who have written on the electrical energy required for ventricular defibrillation have quantified this in terms of the stored energy or the energy delivered through a resistance of 50 Ω from a particular level of stored energy. It has been assumed that the resistance of the thorax is of this order. There is good evidence that this may not always be so, and a value of 75 Ω has been suggested.[16]

That the concept of weight-related dosage is invalid is not surprising, since many factors determine the energy required for defibrillation. Among these are paddle position,[17] paddle size,[18] and the drugs given to the patient.[19] The degree of acidosis and thus the duration of ventricular fibrillation may affect the energy required.[20] In dogs the energy required for defibrillation is related to the time after ligation of the coronary vessel.[21] Clinically many or all of these factors may operate, and it is therefore not surprising to find a lack of correlation of energy requirements with a single factor such as body weight.

The average peak current required for defibrillation in our patients was 0·35±0·03 A/kg. This is in contrast to the suggested 1 A/kg for adults derived from animal studies.[1] Hence it is apparently easier to defibrillate man than other species. Differences in energy requirements between calves and dogs have been reported.[22]

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