


PATTERSON, R. P. (1965) Cardiac output determinations using impedance plethysmography. MS thesis, University of Minnesota, USA.


**1 Introduction**

The measurement of thoracic impedance during defibrillation and cardioversion can be influenced by several factors. These include the delivered energy (EwY et al., 1972), the interface material between electrode and patient (EwY et al., 1977; TACKER and PARIS, 1983), size of electrodes (CONNELL et al., 1973; KERBER et al., 1981), pressure applied to the electrodes (KERBER et al., 1981) number of shocks (GEDDES et al., 1975), time interval between shocks (DAHL et al., 1976) and ventilation phase (EwY et al., 1980).

The effect of any of these factors in isolation can only be studied on animals, where the experimental conditions can be carefully controlled. Unfortunately the quantitative extrapolation of such results to humans seem to be of doubtful validity, as illustrated in the case of the current dose concept proposed by GEDDES et al. (1974), who suggested that the dose of 1 A kg⁻¹ appropriate to many animal species might also apply to humans. This has been shown not to be the case by several investigators, for example PATTON and PANTRIDGE (1979). Although they suggest that a more appropriate dose for humans is 0.35 A kg⁻¹, they could find no correlation between current required to defibrillate and body weight. As suggested by CRAWLEY (1980), data obtained from animal experiments can only provide rough, qualitative guidance.

One factor that may affect the measurement of thoracic impedance, which has not received much attention, is the type of defibrillator used. In a damped sine wave defibrillator this means the values of capacitance, inductance and internal resistance. The importance of quoting these values has been recognised by BABBS and WHISTLER (1978) but it is still uncommon to see all these values quoted in the literature, although the type of defibrillator used may be named.

This communication attempts to show that these values may be of importance in the determination of thoracic impedance.

**2 Data collection and methods**

The two sets of data to be compared were taken from patients on a male cardiology ward. The majority of cases were ventricular defibrillation episodes, but a number of...
cardioversions are included.

The first set of data was collected between 1976 and 1978 using a Cardiac Recorders 61A defibrillator which was modified to provide photographs of patient voltage against current. This modification has been described elsewhere (MACHIN, 1978). A total of 175 photographs were collected, from which the measured peak voltage and current were used to compute initial charge energy and voltage, delivered energy and patient impedance.

A Hewlett-Packard 78670A defibrillator was used in the second study (1984–1986). This model has an annotating recorder which provides a printout of patient impedance, peak current and delivered energy. Two quantities are measured by this defibrillator: peak current during discharge and initial voltage across the capacitor. From the voltage the stored energy is derived and this, along with the current, is used to compute the patient impedance from a microprocessor look-up table (BENNETT and JONES, 1982). This computation assumes that during discharge the impedance is constant, although this is only strictly true in a few cases (MACHIN, 1978). The impedance of the patient decreases as voltage and current increase up to their peak values, the impedance $V/I$ at this point being referred to as the patient impedance. As voltage and current decay the relationship is linear and the impedance shows no further change.

This is the value printed out by the Hewlett-Packard machine; and also the value obtained from the photographs of the earlier experiment. Thus the two sets of results may legitimately be compared. A total of 145 episodes were recorded using the Hewlett-Packard defibrillator.

![Fig. 1: Histograms of patient impedance](image1)

![Fig. 2: Initial charge energy $J_i$ against current $I$](image2)

![Fig. 3: Delivered energy $J_d$ against current $I$](image3)

3 Results

Impedance histograms from the two sets of results are shown in Fig. 1. The Cardiac Recorders histogram conforms to a curve of normal distribution rather better than the Hewlett-Packard histogram, and the mean impedances are 58.2 Ω and 86.8 Ω, respectively. When calculating these mean impedances each countershock has been treated independently, no account being taken of serial shocks on the same patient and no distinction made between the energy levels. The only common denominator is that all the patients were adult males.

Peak discharge current as a function of initial charge energy $J_i$ and energy dissipated in the patient $J_d$ is shown in Figs. 2 and 3. Fig. 4 shows the almost linear relationship between peak current and charge voltage. The correlation coefficient for each of these curves is greater than 0.9. In Fig. 4 it is possible to obtain a good fit through the points with a straight line if the point (0,0) is ignored. This would indicate, however that the impedance of the patient was independent of the amplitude of voltage and current, which was shown (in the earlier experiment) not to be the case in more than 90 per cent of individual episodes. It is therefore unlikely that the mean of these episodes would itself be linear. Moreover, the shape of the curves in Fig. 4 is very similar to that of the rising curves seen in the photographs of the individual episodes using the Cardiac Recorders machine: also the true curve, whatever its shape, must pass through (0,0). A similar argument can apply to the curves of Figs. 2 and 3: if a given patient's impedance were constant for all values of energy, then the peak