A NEW APPROACH TO THE USE OF ELECTROSHOCK DEVICES IN COMBATING VENTRICULAR FIBRILLATION

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In recent years, there has been a burst of activity in the use of electroshock to combat ventricular fibrillation incident to sudden cardiac arrest. In the many instances mentioned in and out of the medical literature, the devices used for shocking the heart have varied from simply a pair of flat retractors connected to an electric light cord to complicated electronically controlled shocking instruments with diverse timing devices. One particular device incorporates the use of suction electrodes to hold the electrodes on the heart.

Although it is undoubtedly true that a number of hearts have been successfully treated by means of retractors connected to the light cord, it is also true that in a number of instances, certain hazards and inadequacies exist, such as: (1) Severe burns of the myocardium have occurred owing to unlimited current flow. (2) Ventricular defibrillation has not been effected because of insufficient current flow at the ordinary supply of 115 volts. (3) Since the operator and patient are not isolated from ground, a possibly serious electric shock may be produced, especially when a program of eliminating static electricity with conductive floors and footwear is in force.

The more complicated units for effecting ventricular defibrillation become involved in possibility of inefficiency on the bases of: (1) fused circuit failure; (2) possible failures in timing circuits or devices, causing failure of shock circuit; (3) trial and error methods of selecting the suitable voltage for successful defibrillation, and (4) inadequate appraisal of actual current flow because of the inability of standard electric instruments, such as ammeters, to indicate correctly short periods of current flow.

It has been established that a minimal current flow of 1 ampere is necessary to effect ventricular defibrillation (1). It is also known that a current of less than 0.8 ampere may possibly produce ventricular fibrillation (2). It has variously been recommended that current values of from 1 to 1.5 (3) or 1.5 to 2.0 amperes (4) should be used for ventricular defibrillation. There is reason to believe that the heart which has undergone anoxia or which is oversized may require more

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than a 110 volt open circuit to be effective in defibrillating the ventricles. Some evidence indicates that this open circuit voltage should be at least 200 volts (5). It is known that an unlimited current flow even at ordinary 115 volt supply can produce burns of the heart.

The standard relationships concerning voltage, amperage, and resistance as expressed by Ohm’s law are: \( I = \frac{E}{R} \). The important element in successful ventricular defibrillation is a proper (adequate but not excessive) current flow. In order to measure the resistance of the heart it would be necessary to apply a minor electric current to the heart and record with a suitable instrument the resistance interposed by the heart. The application of such minor current to the heart under clinical conditions might produce unpredictable effects, perhaps hazardous. Since the \( "R" \) of the human heart is unpredictable and unmeasurable in a given heart under clinical conditions, it would appear that, by merely selecting graded voltage taps, the resultant \( "I" \) depends on the variable \( "R" \) of the heart and any effect may be either inadequate, adequate, or excessive.

It would seem that the more rational approach to providing the proper current flow would be to use a device which has a definite current limitation, while at the same time, the open circuit voltage would be high enough to be effective in any heart in any condition.

The desiderata of an efficient defibrillator would be: (1) to provide sufficient electromotive force for any heart under any conditions: better than 200 volts open circuit. (2) to introduce certain limitations so that, under any circumstance, in operation, the current flow cannot be more than 3 amperes, and (3) as an additional item of data, a signal device without inertia should indicate actual current flow through the heart.

Any unnecessary item which might, by possible failure, interfere with the operation of the instrument should be eliminated. This would include fuses, timers, and so forth.

As a final desideratum, the instrument should be simplicity itself in operation, since the very nature of the emergency should not be further taxed by complicated maneuvers.

These criteria have been answered satisfactorily by the simple and inexpensive design of the Birkmire defibrillator § (fig. 1).

The transformer is of such design that, while providing isolation from ground, the ratio of a one to two degrees circuit is such as to provide an electromotive force of 210 volts on the two degrees side when connected to 115 volt AC 50–60 cycle source. No period of warm up is necessary. At the same time, by virtue of the specific transformer design, no more than 2.8 amperes can possibly flow between electrodes.

Three signal lamps are provided. The first indicates that a patent power source is available and that the transformer is intact: the second

indicates current flow to electrodes on operation of a push switch, and the third is a current intensity indicator which provides direct indication of current flow through the heart at the moment of shock. A bright flare of this indicator denotes a flow of at least 1.5 amperes.

An important element of this design is that if any or all of these indicators should be inoperative, the instrument would still provide the necessary electric shock.

As an additional item to prevent damage to heart muscle, since imperfect electrode contact with the heart results in points of increased current density and consequently possible arcing and tissue burn, the electrodes are slightly curved to more nearly approximate the curve of the heart, and the metal electrodes are covered with cotton boots (ordinary silex filter covers) and saturated with saline solution just before they are applied. This also provides a more even distribution of current over the 7 cm. electrode discs.

To date, 5 patients with ventricular fibrillation have been treated with this device.

**Summary**

The criteria for a new approach to the use of electrical devices for defibrillating a heart in ventricular fibrillation are stated.

An apparatus is described that appears to fulfill the requirements set forth.
REFERENCES


5. Kirby, C. K.: Personal communication to the authors.