Emergency Defibrillation Dose: Recommendations and Rationale

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THE APPROPRIATE ELECTRICAL shock strength (i.e., dose) for transchest defibrillation of adult patients using damped sine wave defibrillators is controversial. Some recommend trying a weak shock first, since an excessively strong shock may cause cardiac damage, leading to a decreased chance of survival or compromised cardiac function. Others recommend trying a stronger shock first, because a shock that is too weak will not defibrillate and, consequently, the increased time before defibrillation decreases the patient’s chances of survival.

As in most controversies, there are data to support both positions, but there are not enough data to resolve the issue. Studies to determine the best shock strength are in progress, and may settle this issue later. Meanwhile, practicing physicians need guidelines for using defibrillators now. We briefly review current knowledge about the effective electrical dose and about cardiac damage from electric shocks, and then suggest a strategy for selecting shock strength that can be used until the appropriate electrical doses are better quantitated. This discussion does not apply to children, who can be defibrillated with low levels of energy, nor to trapezoidal wave form defibrillators, for which effectiveness compared with damped sine wave defibrillators is unknown.

Electrical Dose

There is overwhelming evidence that large experimental animals with no apparent heart disease require stronger shocks for defibrillation than small animals. Also, human pediatric patients can be easily defibrillated with less energy than human adult patients. Studies in hospitalized patients suggested that outputs of greater than 300 J delivered energy might be needed for human use, especially for large patients. There is, however, considerable variation in the shock strength required for individual human and animal subjects, and it has been questioned whether any useful electrical dose relationship can be developed for human adult patients. The variation in shock strength required may be produced by variables other than body weight — for example, disease state,
length of time fibrillation has existed, quality of cardiopulmonary resuscitation, and chest resistance to electrical current flow. These could mask the dose-to-weight relationship. Gascho et al. have shown that energy required for human defibrillation depends on the underlying disease.

Adgey et al. and Crampton et al. have reported high success rates for defibrillation of large and small patients using relatively low energy shocks of 100 or 200 J, although multiple shocks were frequently required to defibrillate. A few patients in their series required full output from a standard 400-J stored energy damped sine wave defibrillator (nominal 300 J delivered). Most physicians use the full 300 J of delivered energy without great concern for producing damage, since death may occur if fibrillation is not corrected rapidly. These two groups of investigators believe that there is no body weight relationship to shock strength and that need for more than 300 J is rare or nonexistent.

However, we disagree with their data. In one series, Adgey et al. reported that 60% of defibrillation attempts were successful with a single 100-J shock (stored energy), and that in another series 85% of attempts were successful with a single 200-J shock (stored energy). In their experience 9% (nine of 102) of episodes could not be defibrillated on the first attempt with a 400-J shock (stored energy). All nine were eventually defibrillated with repeated shocks of 400 J. Adgey et al. conclude that adequate energy is already available from defibrillators because most patients can be defibrillated with 200–300 J. Since duration of fibrillation is inversely related to survival of defibrillated patients, we cannot accept their 15% failure rate for an initial 200-J stored energy shock, especially since there is no evidence that an initial 300-J (delivered energy) shock will produce any damage to the heart.

Other data support the hypothesis that a few patients require more than 300 J delivered energy. In a study of hospitalized patients, Kerber found that many patients could be defibrillated with shocks of 200 J delivered energy or less; but he also found that some patients could not be defibrillated with 300-J shocks, while the same patients could be defibrillated with 400 or 460-J shocks (delivered energy). Hence, the electrical dose required to defibrillate adults apparently varies considerably, i.e., from less than 200 J to more than 400 J. The critical factors that affect this variability have not been identified. Nevertheless, putting aside the relationship of shock strength to weight, a few patients require shocks stronger than 300 J. Based on the data provided by Adgey et al., Crampton et al., and Kerber, we believe that 4 J/kg (delivered energy) is closer to the maximum output needed from defibrillators. This dose is less than the 6.6 J/kg that was first suggested as a guideline.

Cardiac Damage

Any evidence that defibrillator shocks produce damage in humans is extremely important. Defibrillator shocks for human cardioversion have been associated with complications, including ECG changes, elevated serum cardiac isoenzyme levels, and positive cardiac scintigrams; the incidence of these complications is higher with stronger shocks. However, the changes occur without apparent impairment of cardiac function or symptoms of cardiac damage. No report on emergency ventricular defibrillation has shown that such complications occur entirely as the result of shock or that any such complications could be eliminated by weaker shocks. It is very difficult to do such studies in patients, and only data from experimental animals are available. Studies in experimental animals show that a delivered energy dose adequate to defibrillate 95% of subjects produces cardiac necrosis involving only epicardial cells, and only in 5% of subjects. Also, Kerber et al. showed that high-energy shocks do not impair ventricular contractility in experimental animals.

Recommendation

There is no clear answer to the question of how much energy should be administered to adult patients for emergency ventricular defibrillation, but we propose the following protocol:

Except in cases of controlled scientific investigation, shock strengths of 300 J delivered energy should be initially applied for transchest emergency ventricular defibrillation of adults. Only if 300-J shocks fail to defibrillate should higher energy be considered. The number of times that 300-J shocks are tried before using a stronger shock must be left to the discretion of the physician.

There is good rationale for this approach. First, even though the results have probably not been optimal, 15 years of experience with this dose has produced data documenting some degree of success. Second, shocks of less than 300 J carry a definite risk of unnecessarily prolonging cardiac arrest; and, even with cardiopulmonary resuscitation, prolonged periods of arrest are associated with decreased survival rates. Third, use of shocks greater than 300 J carries an unknown and unproven, but probable, risk of inducing cardiac damage in some patients. This risk is acceptable only when the alternative is death of the patient.

We hope that soon the appropriate indications for use of low-energy (less than 300 J) or high-energy (more than 300 J) shocks will be known. We believe that use of more than 300 J by the knowledgeable physician will prolong some lives, but, because of the risk of damage, the higher energies must be used only with appropriate restraint, i.e., after failure to defibrillate with 300 J.

References

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