COMMENTARY

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Are we all clear? Unintended shocks to caregivers during cardiopulmonary resuscitation

Although training in basic life support and advanced cardiac life support emphasizes the importance of ensuring that caregivers are "clear" before shock delivery, there will inevitably be circumstances when they are not. However, to our knowledge, device manufacturers do not address how to manage cases of unintended shock either in their training programs or service manuals. Therefore, the management of caregivers who appear asymptomatic after receiving an unintended shock from a defibrillator remains undefined.

Little has been published in the last decade, and no formal guidelines exist on how to manage this event

WE DON'T KNOW HOW OFTEN IT OCCURS

Reports of unintended shock from defibrillator use during cardiopulmonary resuscitation (CPR) are limited, perhaps because there is no clear avenue for reporting. Also, caregivers may be reluctant to report shocks because they are embarrassed about failing to follow proper protocol.

In one study,[1] the rate of injury was 1 per 1,700 shocks for paramedics and 1 per 1,000 shocks for emergency medical technicians. The incidence for hospital caregivers may be higher, as more caregivers are involved in the code process. Regardless, the paucity of literature and the limited extent of reporting does not allow us to estimate current injury rates.

The use of defibrillators has likely increased since 2015, when the American College of Cardiology and American Heart Association (ACC/AHA) updated their guidelines on cardiopulmonary resuscitation.[2] The guidelines recommend delivering shock within 2 minutes of recognizing a dysrhythmia that is amenable to defibrillation. The ACC/AHA guidelines also stress the importance of continuing chest compressions during defibrillator charge time.[2] In addition, automated external defibrillators are now common in public areas and can be used by people who are not medically trained.

EFFECTS OF ACCIDENTAL SHOCK

Defibrillators are designed to affect electrical activity in the patient's heart, and potentially can affect the caregiver's heart as well. Earlier reports describe a tingling sensation and electrical burns in those who are shocked.[3] However, little has been published within the last decade on this topic, and no formal guidelines or recommendations exist on how to manage this event.

How much exposure?

The electric exposure of the individual largely affects how one perceives the shock and its effects on the body.

The minimal perceptible current detected by the central nervous system is approximately 1 mA but is insufficient for skeletal or cardiac muscle stimulation via transcutaneous exposure. A 1- to 5-mA current is generally perceptible but considered harmless and is un-

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likely to transcutaneously stimulate cardiac or skeletal muscle or burn the skin. A current of 100 to 300 mA, however, will affect skeletal and cardiac muscle and thus can externally induce ventricular fibrillation if present during cardiac repolarization (T wave).

Biphasic defibrillators deliver shock energy up to 360 J. The minimum amount of transcutaneous energy required to induce ventricular fibrillation ranges from 10 to 50 J.

The energy delivered to both the patient and the unsuspecting caregiver depends on the resistance to the current; this is referred to as shock impedance and is measured in ohms. Various factors affect impedance and therefore the amount of shock energy delivered. Clothing and gloves are insulating (have high impedance) and can protect the exposed caregiver from shock energy. Conductive media such as human tissue, metallic objects, or fluids have low impedance and can facilitate shock delivery.

Subcutaneous automated implantable defibrillators are generally ineffective for cardiac defibrillation at shock impedance values over 100 ohms. In a study of 321 patients, the mean impedance on effective shocks that terminated the lethal arrhythmia was 85 ohms vs 104 ohms on ineffective shocks.[4] However, ventricular fibrillation induction is feasible for exposures occurring at lower outputs when timed with ventricular repolarization (T wave), or atrial fibrillation when occurring during atrial repolarization (QRS complex).

Along with the amount of energy supplied, there is a high degree of variability in the level of caregiver exposure. A caregiver could receive a large amount of energy if his or her hand were touching the conductive surface of a paddle, or a small amount if touching a more distal area of the patient with a barrier in place such as gloves. Either way, if the caregiver perceives a sense of electrical impulse, then the caregiver received some unintended degree of energy.

Do gloves protect against shock?

All caregivers should wear personal protective equipment, including gloves, during emergency resuscitation. This helps ensure that if a current is unintentionally conducted through the caregiver's body, the most likely source of entry will be through the gloved hand, which will minimize any current that is shunted from the patient to the caregiver.

A 2016 study examining interruptions in CPR and the utilization of hands-on defibrillation (HOD) reported limited data on emergency personnel being shocked by contact with a patient receiving defibrillation therapy.[5]

Another study examining the conduction of electricity through nitrile gloves found that they did not offer adequate protection from electricity delivered during defibrillation.[6] In an opposing study, it was found that the nitrile pad and neoprene gloves prevented 99% of shocks detectable by the caregiver.[7]

The most common result of these shocks is a tingling sensation and brief paresthesias with associated muscle soreness lasting up to 24 hours.[8] The lack of a perceived current in HOD with exposure to electricity may not ensure that the provider did not receive a shock, which raises questions about the safety of HOD.[9]

HOW TO MANAGE ACCIDENTAL SHOCK

We believe that unintended shocks are highly underreported and may cause more than nuisance-type central nervous system stimulation. Atrial or ventricular fibrillation is possible if the transmitted current density is sufficiently high and the timing is inopportune (ie, during the T wave for ventricular fibrillation, and during QRS for atrial fibrillation). The risk of fibrillation may be further increased in the context of prior cardiac dysrhythmia or underlying structural heart disease. The actual risk is, however, undefined despite a perception that a small amplitude shock is of minimal risk.

We believe shocks are highly underreported and can cause atrial or ventricular fibrillation

Therefore, we advocate for a systematic approach for all caregivers who have received an accidental shock, regardless of severity. This should include a focused history and a limited physical examination to include vital signs, skin assessment, cardiac auscultation, and an electrocardiogram.

Current recommendations in the emergency medicine literature call for an electrocardiogram, urinalysis, complete blood cell count, and a basic metabolic panel[10] to help assess the degree of nonvisible injury. Further imaging studies are recommended based on symptoms.[10] Late arrhythmias have not been shown to be an issue based on current data, and long-term monitor-

ing does not appear to be of great utility.[11] This approach is reasonable for caregivers with obvious injury or residual symptoms, including pain or muscular discomfort, following a shock.

FURTHER RESEARCH NEEDED

Accidental caregiver shock from defibrillator use during CPR is likely to be grossly underreported. Guidance is needed for the systematic reporting of these cases and for proper medical management. Further clinical research and studies are needed to fully understand the risks and consequences of these events, as they may represent a public health concern and certainly an occupational hazard for healthcare providers.

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